



# Template-Engineered Macrocyclic Schiff-Based Metal Complexes: Synthesis, Antibacterial and DNA Photo cleavage Efficacy

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## ABSTRACT

The present study has employed template methodology to synthesize Fe(III) and Cr(III) tetraazamacrocyclic-[N<sub>4</sub>] macrocyclic complexes derived from o-phenylenediamine. In addition to the elemental analysis measurements, the synthesized complexes were thoroughly characterized by spectroscopic and physico-analytical techniques like IR, UV-visible, ESI-MS, Powder XRD, magnetic moment, and molar conductance. Molar conductance values, which provide information on the 1:2 electrolytic behavior, and ESI-MS are used to clarify the monomeric nature of macrocyclic scaffold. Diffractogram reveals the crystalline nature of complexes with crystallite size. The aforementioned studies yielded decent results when the compounds were further screened for their antibacterial potency against a few strains of bacteria. Furthermore, DNA cleaving assays were conducted to clarify the potential of DNA cleaving of recently synthesized complexes.

**Keywords:** Template, Macro cycles, Anti-bacterial, DNA photo cleavage, X-ray diffraction.

## INTRODUCTION

The chemistry of aza-macrocyclic compounds is booming day by day and becoming field of immense interest for researchers of inorganic and medicinal chemistry in all over the world because of their application in various fields of chemistry and biology[1][2]. The importance of o-phenylenediamine (OPD) derivative in field of macrocyclic chemistry, pharmaceuticals and biomedical sciences has been reported by many researchers, as they are used in synthesis of corrosion inhibitors, fungicides, bactericidal, polymer and also for other pharmaceutical applications[3]. OPD derivatives are well known for their importance in synthesis of various schiff bases and heterocyclic drugs. These OPDs have excellent DNA binding profile in macrocyclic chemistry[4]. Mn(II) based OPD macrocyclic



**Purti Mishra and Pooja Sethi**

complexes act as potential T<sub>1</sub>- MRI contrast agent[5]. Lanthanide complexes of OPD derivatives are also very useful in various biomedical fields[6]. In last decades, a variability of complexes is designed and synthesized using OPDs in field of macrocyclic chemistry. Nonetheless, still lots of challenges persists that were not resolved by the present complexes. Therefore, in this field research and development are highly recommended for the synthesis of effective and potent macrocyclic complexes with various application. Macrocyclic compounds have good coordination behaviour with high thermodynamic and kinetic stability that's why it proves as excellent compound in various biomedical fields. So, the objective of present work is as follows:

1. Synthesis of trivalent macrocyclic complexes via template methodology using OPD with succinimide and OPD with phthalic anhydride.
2. Characterization of synthesized complexes by various physico-chemical studies.
3. Study of antibacterial and DNA photo cleavage activity of newly synthesized macrocyclic complexes.

**MATERIALS AND METHODS****Materials**

All the chemicals and solvents used in synthesis procedure were of the AR grade. Succinimide, phthalic anhydride were obtained from CDH Chemicals and o-phenylenediamine from SD Fine Chem Ltd, Mumbai. Metal salts were procured from Qualikems, CDH Chemicals, Chemigens Research & Fine Chemicals and SD Fine Chem Ltd. All the chemicals were utilized in same form as it's received.

**Synthesis of complex**

The novel series of aza-macrocyclic metal complexes were synthesised via template methodology of synthesis. In first step, in hot stirred methanolic solution of OPD (1.081 g, 10 mmol) trivalent iron and chromium salt (5 mmol) added i.e. dissolved in minimum quantity of methanol. After that, resulting mixture was refluxed for near about one hour. A slight change in reaction mixture color, indicating metal amine coordination during the reaction, allowed observers to track the progress of the reaction. Afterward, hot stirred methanolic solution of succinimide (0.9909 g, 10mmol) or phthalic anhydride (1.481g, 10 mmol) were added to the above refluxing reaction solution and continued the refluxing for 9-10 hour. Kept the reaction mixture for overnight cooling, that resulted into precipitation of reaction mixture. Resulted precipitate was further filtered and washed with MeOH, EtOH and diethyl ether and finally dried in vacuum. The yield of synthesized complexes was about 40- 60 %. The solubility of obtained complexes was observed good in DMF, DMSO, acetonitrile and insoluble in the most of common solvent like ethanol, methanol and chloroform. The synthesis scheme of complexes may be depicted by Fig. 1a &1b.

**Analytical and physical measurements**

Melting point of the synthesized complexes were observed on electrical melting point apparatus present in lab. Molar conductivity was recorded on EI 181 digital conductivity meter existing in lab using DMSO as solvent. Magnetic measurements were taken over vibrating sample magnetometer (Model PAR 155) at SAIF, IIT, Roorkee. IR spectra of obtained compounds were recorded by schimadzu IR spectrometer in range of 4000-200 cm<sup>-1</sup> consuming KBr pellet and electronic spectra of complexes were recorded by schimadzu UV 1800 spectrophotometer at CLIR, MM(DU) Mullana. The mass spectra of synthesized complexes were recorded on Q to F micro waters LS-MS at SAIF, Punjab University Chandigarh, India. The elemental analyses were recorded over CHNS elemental analyzer Flash 2000 series at CIL Punjab University, Chandigarh. The diffractogram was recorded at SAIF, Punjab University, Chandigarh on X-ray Diffracto meter model X'Pert Pro. Experiments on gel electrophoresis cleavage were conducted using oxygen electrophoresis, which was powered by a Genei power supply with a potential range of 50–5000V.





### Purti Mishra and Pooja Sethi

#### Biological studies

Two of the most common human pathogens were used for the initial testing: *S. aureus* (MTCC 731), a common Gram-positive human pathogen, and *E. coli* (MTCC 739), a fecal contaminant. All of the complexes were assessed for their antimicrobial activity. Additionally, analysis of the effects of the metal complexes on the genomic DNA (extracted from the corresponding bacterial strains) was done in order to learn more about how these entities affect microorganisms. In this context, plasmid DNA for cleaving investigations and bacterial strains, both Gram-positive (*S. aureus*) and Gram-negative (*E. coli*), were obtained from the CLIR, MM(DU) Mullana.

#### Anti-bacterial screening

Gram-positive (*S. aureus* MTCC 731) and Gram-negative (*E. coli* MTCC 739) bacterial strains are used in the current screening. Using DMSO as the solvent, different concentrations of the complexes (10–200 mg/ml) were prepared to assess the antibacterial properties of the metal complexes using the well diffusion method[7][8]. As per the experimental conditions, the inhibition zone was measured after a 24-hour incubation at temperatures between 35°C and 37°C.

#### DNA cleaving studies

The metal complexes were dissolved in DMSO to create concentrated solutions. All complexes were then dissolved in a suspension made of plasmid DNA, EDTA (TE) buffer, and Tris. The reaction solutions were meticulously prepared in micro-centrifuge tubes made of polyethylene and subjected to UV irradiation (265 nm) on a trans illuminator surface for a quarter of an hour. One gram of agarose was dissolved in one hundred milli liters of 1×TAE buffer to create the gel matrix. The mixture was then heated to about 55°C before ethidium bromide (5 mg/0.5 ml) was added. After that, the mixture was put into a gel cassette that had a comb on it and left to solidify. It was then put into an electrophoresis chamber that had TAE buffer in it. All samples were combined with loading dye and cautiously loaded into wells with untreated DNA samples in preparation for the electrophoresis process. The bands were visible under a trans illuminator following an hour and a half of electrophoresis work[9].

## RESULTS AND DISCUSSION

### Chemistry

#### (AP01) $[\text{Cr}(\text{C}_{28}\text{H}_{16}\text{N}_4\text{O}_2)\text{Cl}]\text{Cl}_2$

Yield ~ 46%, Color = Forest green, M.wt. = 599, M. pt. = 273°C; Analytical Calculation: Cal. M= 8.68; C= 56.16; H= 2.69; N= 9.36. Found M= 7.63; C= 55.14; H= 2.07; N= 8.22. Molar conductivity in DMSO 172  $\text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$ . Magnetic moment  $\mu_{\text{eff}}$  (BM): 4.35.

#### (AP02) $[\text{Fe}(\text{C}_{28}\text{H}_{16}\text{N}_4\text{O}_2)(\text{NO}_3)](\text{NO}_3)_2$

Yield ~ 65%, Color = Dark brown, M.wt. = 682, M. pt. = 288°C; Analytical Calculation: Cal. M= 8.18; C= 49.29; H= 2.36; N= 14.37. Found M= 7.81; C= 48.25; H= 2.04; N= 13.77. Molar conductivity in DMSO 170  $\text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$ . Magnetic moment  $\mu_{\text{eff}}$  (BM): 5.61.

#### (AP03) $[\text{Fe}(\text{C}_{28}\text{H}_{16}\text{N}_4\text{O}_2)\text{Cl}]\text{Cl}_2$

Yield ~ 58%, Color = Brown, M.wt. = 603, M. pt. = 273°C; Analytical Calculation: Cal. M= 9.27; C= 55.80; H= 2.68; N= 9.30. Found M= 8.71; C= 54.56; H= 2.07; N= 8.18. Molar conductivity in DMSO 154  $\text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$ . Magnetic moment  $\mu_{\text{eff}}$  (BM): 5.69.

#### (AS01) $[\text{Cr}(\text{C}_{20}\text{H}_{18}\text{N}_6)\text{Cl}]\text{Cl}_2$

Yield ~ 53%, Color = Teal blue, M.wt. = 501, M. pt. = 238°C; Analytical Calculation: Cal. M= 10.38; C= 47.97; H= 3.62; N= 16.78. Found M= 9.17; C= 46.77; H= 3.12; N= 15.82. Molar conductivity in DMSO 172  $\text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$ . Magnetic moment  $\mu_{\text{eff}}$  (BM): 4.37.

#### (AS02) $[\text{Fe}(\text{C}_{20}\text{H}_{18}\text{N}_6)(\text{NO}_3)](\text{NO}_3)_2$

Yield ~ 57%, Color = Brown, M.wt. = 584, M. pt. = 261°C; Analytical Calculation: Cal. M= 9.56; C= 41.11; H= 3.11; N= 21.58. Found M= 8.63; C= 40.07; H= 2.99; N= 20.45. Molar conductivity in DMSO 167  $\text{ohm}^{-1} \text{cm}^2 \text{mol}^{-1}$ . Magnetic moment  $\mu_{\text{eff}}$  (BM): 5.67.





### Purti Mishra and Pooja Sethi

#### (AS03) [Fe(C<sub>20</sub>H<sub>18</sub>N<sub>6</sub>)Cl]Cl<sub>2</sub>

Yield ~ 49%, Color = Rust color, M.wt. = 505, M. pt. = 255 °C; Analytical Calculation: Cal. M= 11.07; C= 47.60; H= 3.60; N= 16.65. Found M= 10.75; C= 46.23; H= 3.01; N= 15.45. Molar conductivity in DMSO 153 ohm<sup>-1</sup> cm<sup>2</sup> mol<sup>-1</sup>. Magnetic moment  $\mu_{\text{eff}}$  (BM): 5.72.

#### Molar conductance

Molar conductance of all synthesized complexes was measured at a concentration of 0.001 M in DMSO. For Cr(III) and Fe(III) complexes, the measured conductance values fell between 153-172 Ohm<sup>-1</sup> cm<sup>2</sup> mol<sup>-1</sup>, indicating that these complexes are 1:2 electrolytes[10].

#### Electronic spectra and Magnetic moment

Electronic spectrum and magnetic moment data are very helpful in predicting the geometry of the schiff base complexes. Electronic spectrum of all the synthesized complexes were recorded using DMSO as solvent. It has been found that the magnetic moment of the Cr(III) complexes are 4.35-4.37 B.M., which is within the range predicted for the presence of three unpaired electrons. Four peaks at 630-650, 420-450, 340-350 and 240-270 nm in the complexes of Cr(III) electronic spectrum correspond to <sup>4</sup>B<sub>1</sub>→<sup>4</sup>E<sub>a</sub>, <sup>4</sup>B<sub>1</sub>→<sup>4</sup>B<sub>2</sub>, <sup>4</sup>B<sub>1</sub>→<sup>4</sup>A<sub>2</sub> and <sup>4</sup>B<sub>1</sub>→<sup>4</sup>E<sub>b</sub> respectively, indicating square pyramidal geometry (Fig. 2). The peaks in the Fe(III) complexes at 800-850, 550-600, 320-390 nm, which can be ascribed to various bands as d<sub>xy</sub>→d<sub>xz</sub>, d<sub>yz</sub> and d<sub>xy</sub>→d<sub>z</sub><sup>2</sup>, imply square pyramidal geometry to Fe(III) complexes. The magnetic moment value of the Fe(III) Complexes are 5.61-5.72 BM, which is within the range to corresponds the five unpaired electrons with predicted high spin values[11][12].

#### Infra-red spectra

With the aid of the infrared spectrum, it is simple to comprehend the initial interpretation for the condensation of the diamine and dicarbonyl group. There is strong evidence for condensation because the characteristic absorption band for free amine and carbonyl group does not appear at near 3400 cm<sup>-1</sup> and near 1700–1720 cm<sup>-1</sup> respectively; and only a medium to sharp intensity band appears at approximately 1490–1530 cm<sup>-1</sup> due to formation of azomethine linkage (-C=N)[13][14]. A small drift in the absorption frequency values indicates that the nitrogen in the macrocyclic complex is coordinated with the central metal ion. The C-N stretch manifested itself within the range of 1350–1000 cm<sup>-1</sup>. The compounds exhibit a band in the 450–420 cm<sup>-1</sup> region in their far-infrared spectra, which may be the result of M-N vibrations verifying the coordination via the nitrogen of the azomethine group. In every nitrate complex, the band detected at 250–220 cm<sup>-1</sup> was attributed to metal-oxygen vibrations, while the band detected at 300–320 cm<sup>-1</sup> might be related to M-Cl vibrations[15].

#### ESI-MS

In order to provide the structural details of the species that are being studied, the mass spectra of the complexes were recorded using this spectroscopic technique[16]. This method can help to clarify whether the complexes are monomeric or polymeric[17]. Mass spectrum of AP02 and AS01 exhibit m/z molecular ion peak at 682.12 and 501.83 respectively due to the [M+1]<sup>+</sup>. Complex AS01 showed molecular ion peak at m/z value at 472.34, 444.97 because of [M-C<sub>2</sub>H<sub>4</sub>]<sup>+</sup> and [M-C<sub>4</sub>H<sub>8</sub>]<sup>+</sup> respectively; whereas peak due to [M-C<sub>6</sub>H<sub>4</sub>]<sup>+</sup> and [M+2H]<sup>+</sup> observed at 605.16 and 683.18 corresponding to complex AP02.

#### P-XRD

The XRD method is a significant characterization technique that is used to identify the crystalline nature of the materials. It was found mainly, that the design of macrocyclic complexes changes from its metal complex and leads into the formation of particular crystal structure. Powder X-ray Diffraction analysis of one of the Cr(III) metal complex i.e. AS01 was carried out by scanning it between Bragg's angle 2θ = 5° and 90°. The XRD pattern of the metal complex shown in Fig. 3 tells us about the crystalline nature of the compound. In the diffractogram intense and medium to sharp peaks shown with maxima at the value of 2θ 9.007° and 17.137° indicate the presence of Fe(III). These sharp peaks show the crystalline nature of compound. Similar outcomes were also found by some other researches[18][19]. The Debye Scherrer formula,  $D = K\lambda/\beta\cos\theta$  (where D is normal or average crystallite size, K is Scherrer constant, λ(0.15406) is the employed for X-ray wavelength, and β is the full width half maximum), has been





**Purti Mishra and Pooja Sethi**

used to forecast the normal crystallite size from notable peaks[20]. The complex AS01 has a crystallite size of 33.67 nm, which denotes the coordinated compounds with nano crystalline phase.

**BIOLOGICAL RESULT AND DISCUSSION****Antibacterial assay**

The antibacterial potential of each novel macrocyclic complex was tested against two types of bacteria: Gram-positive *S. aureus* (MTCC 731) and Gram-negative *E. coli* (MTCC 739). In order to understand the bactericidal effect of synthesized macrocyclic scaffold on both Gram-positive and Gram-negative bacteria, ampicillin is used as the standard reference medication. While strong activity was seen against *S. aureus* (Gram-positive bacteria) as shown in Fig. 4 and Table 1, although all complexes showed no activity against the tested strains of *E. Coli* (Gram-negative bacteria). Results shows potent activity at concentrations between 40 mg/ml and 200 mg/ml against *S. aureus* by metal complexes AP02, AP03 and AS01. On the other hand, AP01 demonstrated a moderate level of activity at concentration 20mg/ml to 120mg/ml while at concentration 200mg/ml good potential exhibited by AP01 and AS02 both.

**DNA photo cleavage Activity**

The potential discovery of chemical nuclease to defeat cancer is the world's most urgent concern right now. The effect of trivalent transition metal complexes on DNA photo cleavage has been studied. These complexes are well-known for their strong nuclease activities and particular DNA binding abilities. The results of DNA photo cleavage experiments show that metal complexes AP02, AP03, and AS02 have strong DNA photo cleavage abilities. The AS03 macrocyclic complex exhibits a moderate degree of DNA cleavage.

**CONCLUSION**

Fe(III) and Cr(III) macrocyclic complexes were synthesized with good yield. Every complex displayed square pyramidal geometry and a monomeric nature. The results of DNA photo cleavage activity indicate the good DNA cleavage activity of Fe(III) complexes as compared to Cr(III) complexes. PXRD data shows that the nano crystalline nature of complexes. All of the complexes showed good antimicrobial activity, and after determining their cell toxicity, they might be employed as chemotherapeutic agents in the future.

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**Purti Mishra and Pooja Sethi**

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Purti Mishra and Pooja Sethi

Table 1. Zone of inhibition diameter of novel metal complexes against *S. aureus* (Gram-positive bacteria)

Complex	Zone diameter measurement at different concentrations of the metal complex (in mm)						Drug
	10mg/ml	20mg/ml	40mg/ml	80mg/ml	120mg/ml	200mg/ml	
AP01	0	13	13	18	18	22	30
AP02	11	16	20	20	26	27	30
AP03	11	17	20	20	26	28	30
AS01	5	13	19	20	23	21	30
AS02	0	0	0	6	15	22	30
AS03	0	2	0	5	12	14	30

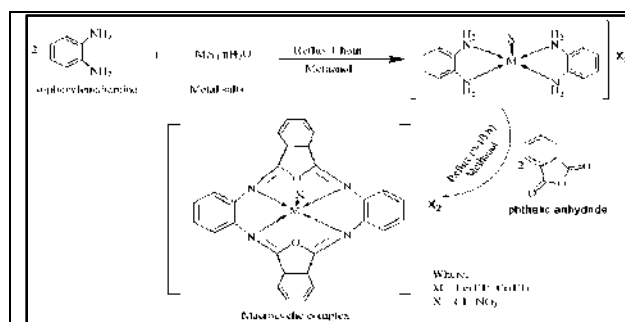


Fig. 1a: Synthetic route to prepare complexes from o-phenylenediamine and phthalic anhydride.

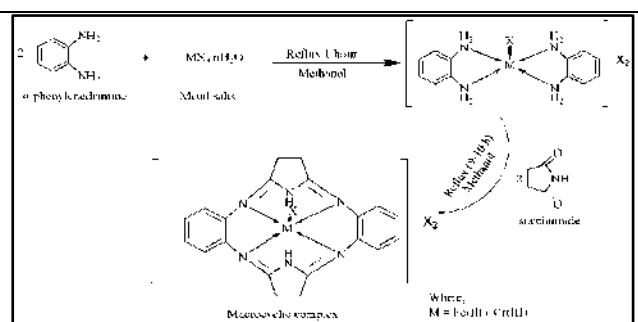


Fig. 1b: Synthetic route to prepare complexes from o-phenylenediamine and succinimide.

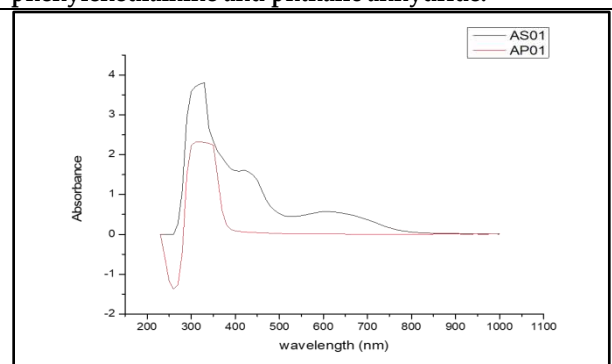


Fig. 2:UV-visible spectra of Cr(III) metal complexes.

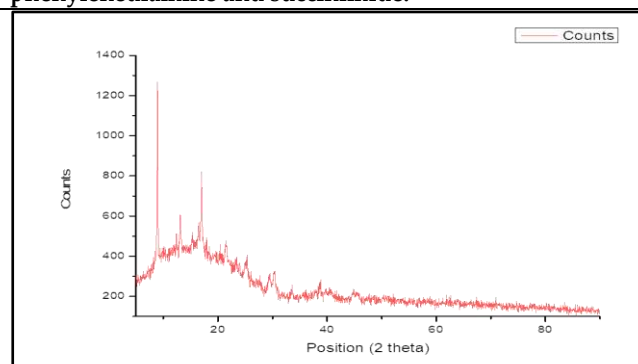


Fig. 3:Diffractogram of macrocyclic complex AS01.

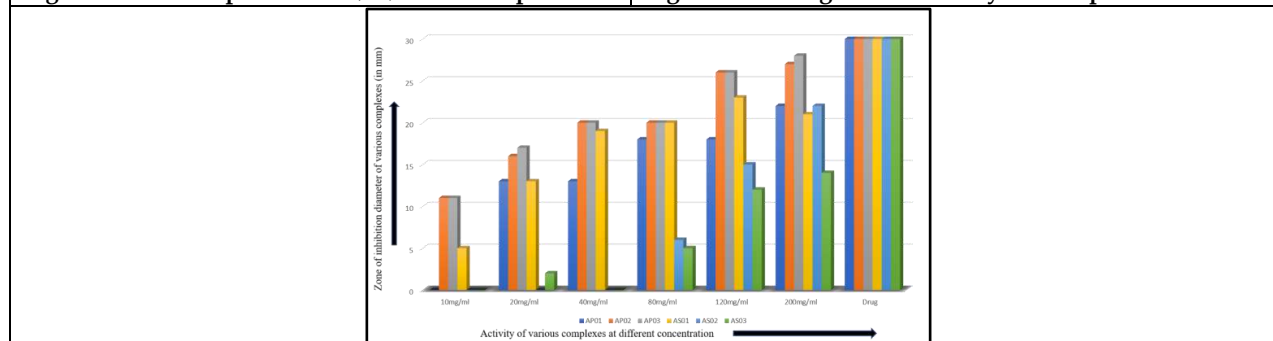


Fig. 4: Graphical representation of antibacterial potential of macrocyclic complexes at different concentration against *S. aureus*.





## Synthesis, Characterization and Neurotoxicity Screening of the Complexes Derived from Thiazole based Ligand

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### ABSTRACT

The present study deals with the synthesis of three metal complexes of the Schiff base derived from 2-aminothiazole and 2-ethoxybenzaldehyde. The structure of the ligands and its metal complexes have been experimentally confirmed by elemental analysis, mass spectrometry, spectroscopic methods like UV-Vis and FTIR as well as magnetic measurement studies. The synthesized ligand was used for chelation with Mn(II) and Co(II) ions in 2:1 (ligand : metal) molar ratio, whereas with Cu(II) in 1:1 (ligand : metal) molar ratio respectively. The elemental, spectroscopic and magnetic studies confirmed the formation of square planar geometry around the Cu(II) ion, octahedral geometry around Mn(II) and Co(II) ion respectively. The neurotoxicity screening of compounds was screened using neuro blastoma SH-SY5Y cell lines and it indicates that the cells were non-toxic either for ligands and complexes after 24 hours exposure. The results showed that all the metal chelates exhibit more cyto toxicity in contrast with free ligands. The chelation was the significant reason for their high cyto toxicity. These results indicated that the thiazole based metal chelates could be exploited as anticancer agents.

**Keywords:** 2-aminothiazole, 2-ethoxybenzaldehyde, EPR, FTIR, Neurotoxicity Screening



**Praveen Kumar Gupta**

## INTRODUCTION

Thiazole is a heterocyclic ring having nitrogen and sulfur at 1<sup>st</sup> and 3<sup>rd</sup> positions in the ring, is well recognized in the literature due to its biological significance. Penicillin is the oldest known antibiotic having a thiazole moiety [1]. Similarly, vitamin B1 also contains a thiazole ring. Thiazoles, when coordinated with metal ions exhibits various biological activities [2] including antioxidant, anti-inflammatory, antitubercular and also found to show a significant improvement in the toxicological and pharmacological properties [3]. 2-aminothiazole derived from thiazole is a significant scaffold found as a basic intermediate formed during the synthesis of various pharmaceutical drugs and having broad biological spectrum [4]. The literature reveals that various Schiff bases have been synthesized from 2-aminothiazole and variety of aldehydes. For example: biological activity of Schiff base derived from 2-hydroxy-1-naphthaldehyde [5]; Schiff base obtained from 2-aminobenzothiazole with curcumin have been found to exhibit antimicrobial profile [6] etc.. Aminothiazole Schiff bases have a significant importance because of their widespread biological applications which includes antimicrobial, anti diabetic [7], antiviral [8], anti platelet [9] and anti tuberculosis [10] etc. Thiazole derivatives are also known to have significant cytotoxic effect and many derivatives have been prepared for targeting specific pathways. An example of these Thiazole containing compounds that have been introduced into cancer therapy are Dasatinib and Dabrafenib which promotes tyrosine kinase inhibitory activity [11, 12]. Owing to the ubiquitous use of thiazole moiety in drugs and natural product, we herein report a new thiazole derived Schiff bases obtained by the condensation of 2-aminothiazole with 2-ethoxybenzaldehyde and its transition metal complexes with Cu(II), Mn(II) and Co(II) metal ions to scrutinize their anticancer properties. The prepared metal based thiazole Schiff base were characterized by elemental analysis, spectral studies and magnetic measurements. These compounds are then screened for their toxicity screening on SH-SY5Y neuro blastoma cell lines for 24 hours treatments.

## MATERIALS AND METHODS

2-aminothiazole and 2-ethoxybenzaldehyde were obtained from Sigma Aldrich. The purity of the Schiff base ligand was detected by using the thin layer chromatography (TLC) technique. The FTIR spectra samples were recorded in the range of 400-4000 cm<sup>-1</sup> on a Shimadzu FTIR spectrometer. A high-tech Shimadzu Spectrophotometer was employed for the UV-Vis analysis of all the synthesized compounds. EPR spectrum was recorded by JEOL Model JES FA200 instrument. Magnetic moments of complexes were determined on Sherwood Auto Magnetic susceptibility balance. Dulbecco's Modified Eagle Medium (DMEM) and Minimum Essential Medium (MEM), Dimethyl Sulphoxide (DMSO), Fetal Bovine Serum (FBS), Phosphate Buffer Saline (PBS), and (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) were procured from Himedia (Mumbai, India). SH-SY5Y neuroblastoma cell line was procured from the National Centre for Cell Sciences, Pune, India. The cells were cultured in DMEM medium containing 10% heat-inactivated FBS and penicillin/ streptomycin solution (100 units/ml and 100 mg/ml respectively) at 37°C in a humidified, 5% CO<sub>2</sub> atmosphere.

### Synthesis of 1-(2-ethoxyphenyl)-N-(thiazol-2-yl)methanimine

2-Ethoxybenzaldehyde (1.5g, 10 mmol) and 2-aminothiazole (1.0g, 10 mmol) were dissolved in minimum amount of ethanol and both the solutions were added to round bottom flask. The mixture was refluxed on water bath for 1 hr. The brown coloured precipitate obtained was cooled to room temperature, washed with hot ethanol and methanol and finally dried in an oven. The purity of ligand was preliminarily observed by thin layer chromatography in 10:2 mixture of Hexane and ethylacetate solvent.

### General method of synthesis of copper, manganese and cobalt complex derived from 1-(2-ethoxyphenyl)-N-(thiazol-2-yl)methanimine

1-(2-ethoxyphenyl)-N-(thiazol-2-yl)methanimine (2.32 g, 10mmol) was dissolved in 30 ml methanol. CuCl<sub>2</sub>·2H<sub>2</sub>O (1.34 g, 10 mmol)/ or Mn(CH<sub>3</sub>COO)<sub>2</sub>·4H<sub>2</sub>O (0.87 g, 5mmol)/or CoCl<sub>2</sub>·6H<sub>2</sub>O (1.2 g, 5mmol) was also dissolved in minimum amount of methanol and then added to the above solution. The mixture was then refluxed on water bath







### Praveen Kumar Gupta

for 1 hr. The precipitates obtained were filtered and washed with ethanol and methanol and finally washed dried in oven at 80°C.

#### Cell viability assay

SH-SY5Y cancer cells ( $1 \times 10^4$ ) were cultured in the 96-well plate and allowed to adhere overnight. Cells were then treated with specific medium at different concentrations (25, 50, 100 and 200  $\mu\text{g/ml}$ ) for 24 h, followed by washing with PBS to remove dead cells. Untreated cells were used as negative control, and Vincristine sulfate (5  $\mu\text{g/ml}$ ) treated cells were positive controls. MTT assay was carried out three times in triplicate as described earlier [14]. The percentage of cell death was calculated by using the formula given below:

$$\% \text{Cell death} = [\text{OD control} - \text{OD sample}] / \text{OD control} \times 100$$

Where, OD control is the absorbance of untreated cells and the OD sample denotes absorbance of treated cells.

## RESULTS AND DISCUSSION

An outline for the synthesis of the Schiff base and its metal(II) complexes are shown in **Scheme 1** and **2**. Ligand and its metal complexes are coloured, solid and stable at room temperature. On heating at high temperature, they get decompose and are more or less soluble in common organic solvents. Analytical data of the ligand and complexes, together with physical properties are comparable with the proposed molecular formula. Manganese complexes has 1:2 (metal:ligand) stoichiometry whereas copper and cobalt complexe sexhibit 1:1 (metal:ligand) stoichiometry (Table 1). FTIR peak positions of the Schiff base and its complexes were assigned as given in Table 2. A peak at 1620  $\text{cm}^{-1}$  was assigned to azomethine linkage in the ligand which get shifted by 10-20  $\text{cm}^{-1}$  in the complexes indicating the coordination of the azomethine nitrogen to the metals ions. Similarly, the peak at 1255  $\text{cm}^{-1}$  which get shifted by 10-14  $\text{cm}^{-1}$  in the complexes were assigned to  $\nu(\text{C-O})$  bond of the ethoxy group[14]. In cobalt(II) complex, the two band due to  $\nu_{\text{sy}}(\text{COO})$  and  $\nu_{\text{asy}}(\text{COO})$  at 1390  $\text{cm}^{-1}$  and 1595  $\text{cm}^{-1}$  confirms the coordination of acetate ion. Metal-oxygen  $\nu(\text{M-O})$  and metal-nitrogen  $\nu(\text{M-N})$  stretch in case of complexes were observed in the range 557-562  $\text{cm}^{-1}$  442-465  $\text{cm}^{-1}$  respectively. In addition, showed bands within (3014-3063  $\text{cm}^{-1}$ ) assign to  $\nu(\text{C-H})$  aromatic. In ligand, peak at 1359  $\text{cm}^{-1}$  due to  $\nu(\text{C-N})$  and a peak at 741  $\text{cm}^{-1}$  due to  $\nu(\text{C-S})$  were observed which remain unchanged in metal complexes.

#### Electronic spectra and magnetic measurements

The electronic spectra of the ligand [L] exhibits strong peaks at 272 and 338 nm (Table 3) assigned due to intra-ligand  $\pi-\pi^*$  and  $n-\pi^*$  transitions respectively. The copper complex  $[\text{CuL}_2]$  showed peak at 690 nm which may be assigned to the  ${}^2\text{B}_{1g} \rightarrow {}^2\text{A}_{1g}$  transition indicating square planar geometry, and the magnetic moment value of 1.81 B.M falls within the range normally observed for mononuclear square planar Cu(II) complexes [15]. The spectrum of cobalt complex  $[\text{CoCl}_2\text{L}_2]$  exhibits absorption peak at 645, 760 and 525 nm due to  ${}^4\text{A}_2(\text{F}) \rightarrow {}^4\text{T}_1(\text{P})$ ,  ${}^4\text{T}_1(\text{F}) \rightarrow {}^4\text{A}_2(\text{g})$  and  ${}^4\text{T}_1(\text{F}) \rightarrow {}^4\text{T}_1(\text{g})$  transitions indicating the octahedral geometry which is further confirmed by its magnetic moment value of 4.83 B.M. indicating monomeric cobalt(II) species having four unpaired electron[16]. In case of manganese complex  $[\text{Mn}(\text{OAc})_2\text{L}_2]$ , band appear at 625 and 440 nm that may be assigned to the spin forbidden  ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{1g}(\text{G})$  and  ${}^6\text{A}_{1g} \rightarrow {}^4\text{T}_{2g}(\text{G})$  transitions respectively [16], indicating an octahedral geometry which is further supported by the magnetic moment value of 5.81 BM typical of the manganese(II) high spin complexes.

#### Electron spin resonance spectra

The EPR spectrum of copper(II) complex  $[\text{CuCl}_2\text{L}]$  shows one intense isotropic absorption band due to tumbling motion of the molecules. However, in frozen state it exhibits four line pattern  $[(2nI + 1) = 4]$ , nucleus spin value  $I = 3/2$  with g values:  $g_{\parallel}$  (2.45)  $>$   $g_{\perp}$  (2.13)  $>$   $g_e$  (2.0023), indicating the unpaired electron present in the  $dx^2-y^2$  orbital and thus suggesting the square planar nature of the complex. ESR parameters of the manganese and cobalt complexes could not be calculated due to low resolution of the splitting pattern.



**Praveen Kumar Gupta****Mass Spectra**

The mass spectra of ligand and their complexes exhibit the molecular ion peak at  $m/z = 332.05, 364.91, 637.07$  and  $593.01$  respectively. The data obtained provide good agreement for the molecular formula of these complexes.

**MTT assay**

The MTT assay revealed the anti-cancer potential of the complexes which get enhanced with an increase in concentrations (25-200  $\mu\text{g/ml}$ ) after 24 hour of incubation on SH-SY5Y neuro blastoma cells (Figure 1). The Cu complex exhibited significantly enhanced neuro blastoma cell killing as compared to other complexes and ligand (even at lower concentration) as depicted by  $\text{IC}_{50}$  values (Table 4) The  $\text{IC}_{50}$  value towards SH-SY5Y cancer cells was indefinable after treatment with ligand. The enhanced cancer cell death via Cu complex suggested that the interaction between this complex and the cancer cells mediated cancer cell death under in vitro conditions.

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**Praveen Kumar Gupta**

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**Table 1. Analytical data for the ligand and its complexes**

Compound	Molecular Formula	Colour	Elemental analysis % Calculated (Found)			
			C	H	N	M
[L]	C <sub>12</sub> H <sub>12</sub> N <sub>2</sub> OS	brown	62.05(61.01)	5.21(5.15)	12.06(11.99)	-
[CuCl <sub>2</sub> L]	C <sub>12</sub> H <sub>12</sub> Cl <sub>2</sub> CuN <sub>2</sub> OS	dark brown	39.31(39.29)	3.30(3.21)	7.65(7.60)	17.33(17.25)
[Mn(OAc) <sub>2</sub> L <sub>2</sub> ]	C <sub>28</sub> H <sub>30</sub> MnN <sub>4</sub> O <sub>6</sub> S <sub>2</sub>	dark brown	52.74(52.69)	4.74(4.67)	8.79(8.71)	8.60(8.53)
[CoCl <sub>2</sub> L <sub>2</sub> ]	C <sub>24</sub> H <sub>24</sub> Cl <sub>2</sub> CoN <sub>4</sub> O <sub>2</sub> S <sub>2</sub>	green	48.47(48.38)	4.08(4.16)	9.43(9.37)	9.90(9.81)

**Table 2. FTIR data for the ligand and its complexes**

Compound	$\nu$ (C=N)	$\nu$ (C-O)	$\nu$ (M-N)	$\nu$ (M-O)
[L]	1620	1254	-	-
[CuCl <sub>2</sub> L]	1610	1265	465	560
[Mn(OAc) <sub>2</sub> L <sub>2</sub> ]	1606	1265	459	557
[CoCl <sub>2</sub> L <sub>2</sub> ]	1600	1268	442	562

**Table 3. Electronic spectral, ESR spectral and magnetic measurement data For the ligand and its complexes**

Compound	Peak Position(nm)	Peak Assignment	$\mu_{\text{eff}}$ (B.M)
[CuCl <sub>2</sub> L]	690	[ <sup>2</sup> B <sub>1g</sub> → <sup>2</sup> A <sub>1g</sub> ]	1.81
[Mn(OAc) <sub>2</sub> L <sub>2</sub> ]	625	[ <sup>6</sup> A <sub>1g</sub> → <sup>4</sup> T <sub>1g</sub> (G)]	5.86
	440	[ <sup>6</sup> A <sub>1g</sub> → <sup>4</sup> T <sub>2g</sub> (G)]	
[CoCl <sub>2</sub> L <sub>2</sub> ]	645	[ <sup>4</sup> T <sub>1g</sub> (F)→ <sup>4</sup> T <sub>2g</sub> ]	4.83
	760	[ <sup>4</sup> T <sub>1g</sub> (F)→ <sup>4</sup> A <sub>2g</sub> ]	
	525	[ <sup>4</sup> T <sub>1g</sub> (F)→ <sup>4</sup> T <sub>1g</sub> ]	

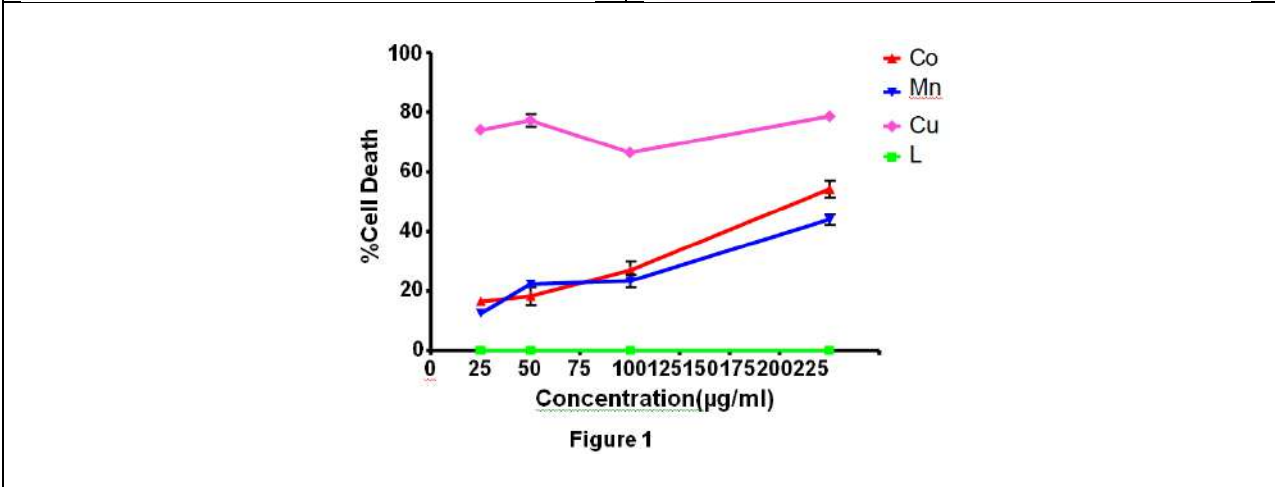
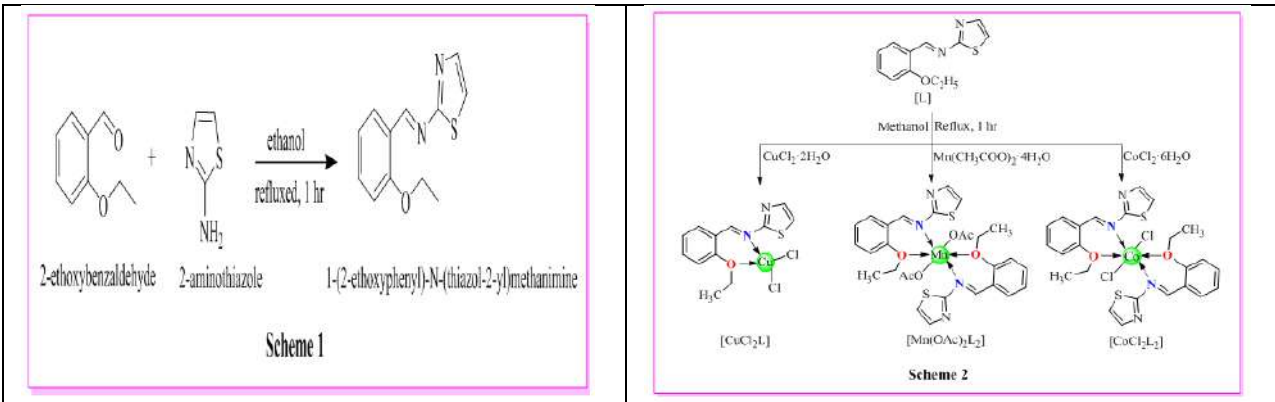
**Table 4. IC<sub>50</sub> values for the ligand and its complexes**

Compounds	Pvalue(two-tailed)	Significant	IC <sub>50</sub> Values
[L]	ND	ND	ND
[CoCl <sub>2</sub> L]	0.0447	Yes	68.82
[Mn(OAc) <sub>2</sub> L <sub>2</sub> ]	0.0306	Yes	54.90
[CuL <sub>2</sub> ]	0.0001	Yes	5.980





**Praveen Kumar Gupta**





## Preparation, Characterization and Evaluation of Bimetallic Zn-Cu Nanoparticles Obtained from Aqueous Seed Extract of *Trifolium alexandrinum* as Novel Pharmacological and Photocatalytic Agents

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### ABSTRACT

The inadequate control and improper use of antibiotics lead to drug resistance in microbes which strongly generate requirement of development of resistance-resistant drugs. In recent years, metallic nano particles have been emerged as potential alternative pharmacological agent due to their broad spectrum activities. Moreover, recent findings identify the enhanced medicinal properties of nano particles obtained from combination of metals and plant products. Present study describes the fabrication, characterization and biological study of bimetallic (Zn-Cu) nano particles by using aqueous seed extract of *Trifolium alexandrinum*. The aim of this study is to prepare nano particles of natural components by using ecofriendly, simple and inexpensive methods. The characterization of Zn-Cu-NPs was observed by using UV, FTIR spectroscopy, XRD, SEM, EDX and TEM analysis. The obtained results demonstrated the formation of homogenous distributed core-shell Zn-Cu structures with spherical and semi crystalline nanoparticles. The extract and nanoparticles were subjected to antimicrobial analysis by using two different strains of bacteria and fungi. Evidences show the excellent antimicrobial behavior of aqueous extracts of *Trifolium alexandrinum* alone but inhibition of bacterial and fungal strains have been increased many folds of time after synergism with Zn-Cu. The synthesized nanoparticles were also found to exhibit promising photo catalytic activity which ultimately makes them useful to treat waste water.

**Keywords:** Nanoparticles, Bimetallic NPs, Waste Water Treatment, Biological Potency, *Trifolium alexandrinum*







Nirantak Kumar et al.,

## INTRODUCTION

metal nano particles are entities made up of pure metals (silver, gold, platinum, zinc, iron, copper etc.) observed at sub-micron scale by using their salts in the form of chlorides, fluorides, oxides, hydroxides, phosphates, sulfides etc. Various methods have been used to synthesize metal nano particles like thermal decomposition method, microwave irradiation, sol-gel method and many more [1]. It has been found that synthetic processes of nano particles obtained from laboratory chemicals are costly and toxic due to production of large amount of waste materials. Hence efforts has been made to synthesize nano particles by using extracts of various parts of plants which are considered as non-toxic and less time consuming processes [2-6]. Nanoparticles has made an important place in the field of research due to their use in various industries like packaging [7], medicine [8], medicinal devices [9], textile engineering [10], water purification [11] and as biological agents [12-13] etc. Metal based nano particles especially derived from various transition metals has attained a considerable attention due to their major applications in clinical and pharmaceutical industry as they acts as inhibitory agents on maximum species of bacteria and fungi [14-15], shows very good optical activity [16], heat transfer [17], high surface area volume ratio [18], magnetic property [19] etc.

Tremendous biological activities like, potential anticancer [20], photo catalytic [21], Ameliorate Defence, Antioxidant [22, 24], anti-diabetic [25], anti-inflammatory [26] and many more activities especially shown by copper and zinc nanoparticles obtained from plant extracts. On the basis of literature survey, seed extract of *Trifolium alexandrinum* has been used to prepare metal based nano particles. *Trifolium alexandrinum* relates to the family *Fabaceae*. Phyto chemical analysis have identifies the presence of proteins, fatty acids, terpenoid glycosides, amino acids and their derivatives, flavonoids and their glycosides and isoflavonoids etc. in extract of plant. Various biological activities i.e. antioxidant, anti diabetic [27] and enhanced wound healing capability in streptozotocin-induced diabetic rats etc. has also been reported in extract of various parts of *T.alexandrinum*[28]. This paper is based upon synthesis of noval bimetallic nano particles by using seed extract of *T.alexandrinum* and combination of two metal (Zn and Cu) salts. The obtained nano particles shows excellent antimicrobial activity. The synthesis moiety was also found to treat waste water on analysis against *Resorcinol* for photo catalytic activity.

## MATERIAL AND METHODS

Zinc and Copper oxides used were of AR grade and purchased from Merck. All the reactions were performed on magnetic stirrer with hot plate. Potato dextrose and Agar-agar were also purchased from Merck. Procured microbial type collection culture (MTCC): institute of microbial technology (IMTECH), Chandigarh. Double distilled water was used while whole process of experimentation. All apparatus were washed properly with double distilled water and dried in hot air oven to prevent any contamination.

### Preparation of Seed extract of *Trifolium alexandrinum*

The extraction of Seed extract of *T. alexandrinum* has been done by previously reported methods [29-30]. Fresh Seed of *T. alexandrinum* were identified and collected from Local market, panchkula, Haryana, India. The Seed were first washed with tap water and then with distilled water. After washing, Seed were dried in shade for 10 days and then converted to fine power using an electric grinder. 15 g of crushed seed were mixed with 100 ml of water in a 200 ml of beaker at room temperature. Mixture was incubated at 25°C for 24 hr. After that content was stirred for 30 minutes at room temperature by using a magnetic stirrer. The obtained dark brown colored content was filtered by using What man No. 1 filter paper. The filtrate was collected in a beaker and preserved at 4°C in a refrigerator for further processes.

### Preparation of monometallic Zinc nanoparticles solution

Cost effective and Very simple method was employed for synthesis of Zinc Oxide nano particles under laboratory conditions. Approximately 100ml of aqueous solution of Zinc nitrate (0.1 M) was prepared and mix with Seed extract





**Nirantak Kumar et al.,**

in a ratio 1:2 (plant extract: Zinc nitrate solution). The 50ml of zinc nitrate solution was added drop wise into 12.5 ml of plant extract solution with continuous stirring for 2 hr. The colour of solution turn light brown which indicate formation of Zn nanoparticles.

#### **Preparation of bimetallic Cu-Zn nanoparticles solution**

100ml of 0.1 M of copper sulphate and 100ml of 0.1 M zinc sulphate solutions were prepared in two different beaker 50ml of each solution was taken collective Cu and added drop wise to the 12.5 ml of seed extract (ZCS). The content was stirred for 2hr. using magnetic stirrer. The colour of the solution turn dark brown to parrot green which the confirm formation of (TXN/ZCS) bimetallic NP. Mixture was allowed to stand undisturbed at room temp. The green ppt obtained were filtered and dried at room temperature.

#### **Photo catalytic activity**

The photo catalytic degradation efficiency ofTXN/ZCSwas examined for the degradation of Resorcinol (RSL)in solar illumination. The photo catalytic activity was performed by a double walled Pyrex glass chamber. 50 mg of nanoparticles was added into  $1 \times 10^{-5}$  M solution of Resorcinol at constant temperature ( $30 \text{ }^\circ\text{C} \pm 1$ ). The mixture was kept in dark to achieve adsorption-desorption equilibrium. Then, the solution was subjected to sunlight and 3mL of aliquot was taken out at different time intervals. The above aliquot was centrifuged to remove nanoparticles and absorbance was noted at specified wavelength [31]. The percent degradation of dye was calculated using formula as

$$\% \text{ Degradation} = \frac{C_0 - C_t}{C_0} \times 100$$

Where  $C_0$  = initial concentration

$C_t$  = instant concentration of dye sample.

The kinetics of degradation was explained by pseudo first order kinetics. The rate constant (k) was calculated by the following equation: Where the slope obtained from the plot of  $\ln A_0 / A$  vs t. Further different parameters like effect of pH of the solution, photo catalyst dosage and concentration of dye were studied and degradation efficiency was calculated.

#### **Antimicrobial activity**

The TXN/ZCS nano particles were tested for antimicrobial susceptibility against gram-negative and gram-positive bacteria *i.e.*, *Salmonella Typhi* and *Bacillus subtilis*, respectively(32). To test antimicrobial activity, agar well diffusion method was used (Swati *et al.*, 2020). To carry out the antimicrobial assay, nutrient broth and nutrient agar was used for the growth of bacteria. Bacteria pre-culture nutrient broth could be left in a rotary shaker overnight at  $35\text{-}37^\circ\text{C}$  for 16-18 hours. The pre-culture broth was spread over nutrient agar media petri plates. With the help of a puncture on the plates, 6mm diameter wells were created. Antimicrobial activity was tested against pathogenic bacteria using different concentrations of TXN/ZCS nano particles *i.e.*,  $25\mu\text{l}$ ,  $50\mu\text{l}$  and  $100\mu\text{l}$  solution (100mg/ml) and  $100\mu\text{l}$  antibiotic solutions (10mg/ml). Furthermore, ampicilin was used as a positive control whereas, triple distilled water serving as a negative control. The Petri plates were incubated at  $37^\circ\text{C}$  for 16-18 hours for the growth of bacteria. All of the tests were carried out in triplicates. Using the HiMedia antibiotic zone scale, the diameters of the inhibition zones obtained around the wells were measured in millimetres (mm).

## **RESULT AND DISCUSSION**

The current report describes the synthesis of Zn-Cu nano particles using seed extract of *T. alexandrinum*. Formation of metal based nanoparticles has been observed by change in color of the solution on addition of seedextract in a solution of Zinc and Copper sulphate. Various analytical and spectral techniques has been used to find the nature and particle size of the prepared nano particles.





**Nirantak Kumar et al.,**

**FTIR:** Fourier transform infrared spectroscopy (FTIR) spectrum of biosynthesized TXN/ZCS shows absorption peaks at 3551.26, 3414.33, 3236.33, 1617.88, 1143.46, 621.09 and 480.84  $\text{cm}^{-1}$ . Figure.1. Strong absorption peak at 3,414  $\text{cm}^{-1}$  is resulted from stretching of the N-H band of aliphatic primary amine groups or is indicative of present O-H groups due to the presence of alcohols, etc. The peak that appeared around 3236  $\text{cm}^{-1}$  is related to the stretching of the O-H bonds. Absorption peak at 1,617 are characteristics for group (C=C). The peak at 1,143  $\text{cm}^{-1}$  may be ascribe to -C-O- stretching modes. The band at 624.30  $\text{cm}^{-1}$  and 456.98  $\text{cm}^{-1}$  are attributed to the presence of Zn and copper stretching band.

#### FESEM and EDX Analysis

Fig.2.(A-B) is TXN shows rough morphology of trifolium alexandrinum. Fig.2.(C-D) are SEM monographs of ZCS shows rectangular shape and also shows the crystalline morphology. The combination of organic part and inorganic part materials can lead to the formation of composite materials with unique properties. Fig.2.(E-F) the resulting TXN/ZCS images obtained through scanning electron microscopy (SEM) exhibit an amorphous morphology. Amorphous morphology refers to a structure lacking long-range order or a definite crystalline pattern. In the composite images, the integration of the organic and inorganic components does not result in a well-defined shape or arrangement. Instead, the materials appear to be randomly distributed, lacking any distinct patterns or crystalline feature. The total weight percentage of the analyzed components sums up to 67.79 wt.%, with carbon and oxygen being the major elements present in the sample. This information can provide insights into the elemental composition and relative abundance of different components in the analyzed material. TEM. TEM analysis was used to examine the surface morphology of the fabricated Cu-ZnSo<sub>4</sub> mixed bimetal. According to TEM the synthesized TXN/ZCS nano particles have a spherical shape with agglomeration. TEM images of the lattice fringes provide confirmation that the produced particles are agglomerated [23]. Figure.4. depicts the TEM image of Cu/Zn after pres entering at 500°C. Furthermore, HRTEM pictures shows that the sample contains TXN/ZCS (24). The TEM images shows that nano particles are formed.

#### XRD

XRD graphs of composite, organic and inorganic are given in **Figure 5**. A number of diffraction peaks with different intensities were observed at 16.7°, 22.07°, 28.11°, 33.42°, 35.73°, 52.58 and 59.0° in the diffraction pattern of ZCS part. Diffraction peaks at 16.7°, 22.07°, 28.11°, 35.73°, 52.58 gets disappeared in the diffract to gram of composite nano particles. A significant amount of variation is shown in the intensity of the peaks at 34.4°, 60.7° and 71.3° in the powdered X-ray diffract to gram of composite. The disappearance and reduction in the intensity of many peaks in TXN/ZCS might be due to the incorporation of the TXN counter part into the ZCS moiety. 5.15% crystallinity of Composite nano particles was calculated by formula.

#### Antimicrobial Activity

Figure.6. Analysis of antimicrobial activity of TXN/ZCS nano particles against different pathogenic bacteria; A- showed antimicrobial activity against *Salmonella Typhi* (gram- negative bacteria), B- showed antimicrobial activity against *Bacillus subtilis* (gram- positive bacteria), whereas, the concentration of TXN/ZCS nano particles was 25  $\mu\text{l}$ , 50  $\mu\text{l}$  and 100  $\mu\text{l}$ ; -ve showed antibacterial activity for negative control; +ve showed antimicrobial activity for positive control (Antibiotic). The present study revealed that the synthesized TXN/ZCS nanoparticles showed antimicrobial activity against both the gram positive and gram negative bacteria. The inhibition zones (in mm) of varying sizes were obtained as mentioned in Table 2 and Figure 6. The inhibition zones were measured by taking the amount of 100  $\mu\text{l}$  of TXN/ZCS nanoparticles solution and ampicillin in a different well. The positive control showed the zone of inhibition against both gram-positive and gram-negative bacteria. In table, gram-negative bacteria showed minimum zone of inhibition as compare to gram-positive bacteria. The positive control showed the inhibition zone of different sizes in different pathogenic bacteria i.e., *Salmonella Typhi* (16.6 $\pm$ 0.58) and *Bacillus subtilis* (17 $\pm$ 0.56) but negative control showed no zone of inhibition.





Nirantak Kumar et al.,

### Photo degradation

The photodegradation activity of TXN/ZCS was determined by investigating the degradation of RSL under natural visible-light irradiation. Figure 7a,b depicts the UV spectra of RSL at different time intervals of light exposure with both TXN/ZCS and ZCS. The intensity of the peak gradually decreases, which suggests a decrease in the concentration RSL. Figure 7c shows the percentage photodegradation of resorcinol as a function of time in the presence of TXN/ZCS and ZCS. It was observed that 90 % of RSL gets degraded over 180 min of solar exposure. The order of RSL degradation is as follows: TXN/ZCS (90.52%)> ZCS (63.15%). The photodegradation process follow PSEUDO-FIRST-ORDER KINETICS, and the plots are shown in fig.7d. The higher value of rate constant for TXN/ZCS was found to be  $0.01773 \text{ min}^{-1}$  as compared to sole counterpart's photo-catalyst. **Fig.8a, b**, RSL being anionic in nature showed greater reaction tendency with photo-catalyst in basic pH. The results showed that at photo-catalyst in basic pH. The results showed that at pH 9.0 maximum degradation rate  $0.03661 \text{ min}^{-1}$  was observed for TXN/ZCS ( $0.01566 \text{ min}^{-1}$  for ZCS). The effect of photo-catalyst dose was studied in the range of 50 to 250mg. figure **8c, d**, exhibits the effect of catalyst loading on % degradation of RSL with TXN/ZCS and ZCS. The maximum rate of RSL was  $0.0361571 \text{ min}^{-1}$  with 150mg of TXN/ZCS loading ( $0.01566 \text{ min}^{-1}$  with 150mg of ZCS). The effect of RSL concentration was studied in the range of 10-90ppm. The rate values at different dye concentrations for TXN/ZCS and ZCS are potted in **Fig. 8 e,f**. The rate of removal of Resorcinol (RSL) for 50 ppm of RSL concentration. As the concentration of RSL, the rate decrease. The decline is because of the scarcity of active sites with an increase in RSL concentration. All active sites get saturated and hinder the photo degradation process.

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Nirantak Kumar et al.,

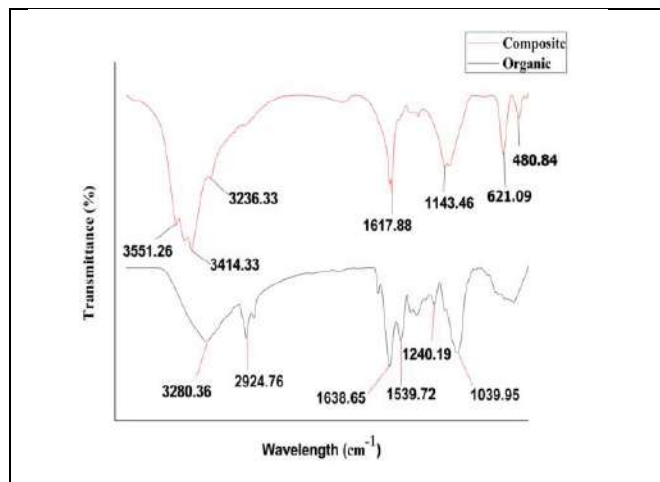
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**Table1.** Based on the provided SEM EDX data, the composition of the analyzed sample is as follows:

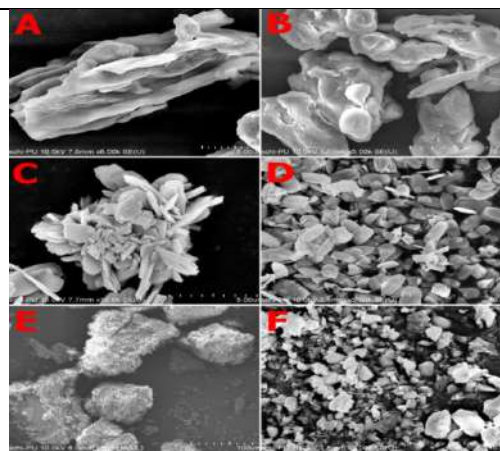
Element	series	Series un. [wt.%]	C norm. [wt.%]	C Atom. [at.%]	C Error (3 Sigma) [wt.%]
Oxygen	K-series	17.21	25.39	34.53	9.59
Carbon	K-series	16.81	24.80	44.93	11.49
Copper	K-series	13.57	20.02	6.85	2.29
Zinc	K-series	12.57	18.55	6.17	2.47
Sulfur	K-series	5.21	7.69	5.22	0.74
Phosphorus	K-series	1.49	2.20	1.54	0.33
Potassium	K-series	0.92	1.35	0.75	0.25
	Total	67.79	100.00	100.00	

**Table.2.** Inhibition zones (mm) of TXN/ZCS nano particles against gram-positive and gram-negative bacteria

Bacteria	25µl	50µl	100µl	Positive control	Negative control
<i>Salmonella Typhi</i>	18±0.55	21±0.56	23±0.67	16.6±0.58	ND
<i>Bacillus subtilis</i>	20±0.53	24±0.48	27±0.54	17±0.56	ND



**Figure1.** FTIR of TXN/ZCS, TXN



**Figure 2.** SEM image of a,b TXN c,d ZCS e,f TXN/ZCS



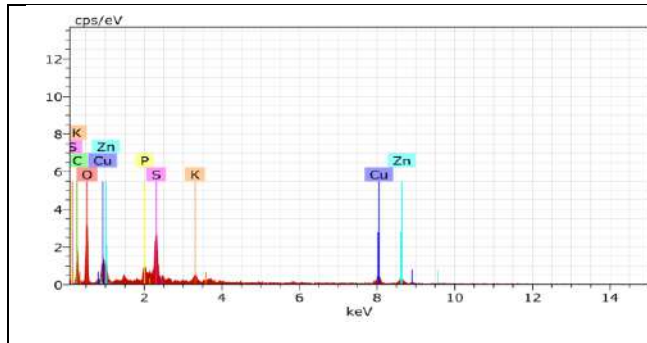


Figure.3.EDXof TXN/ZCS

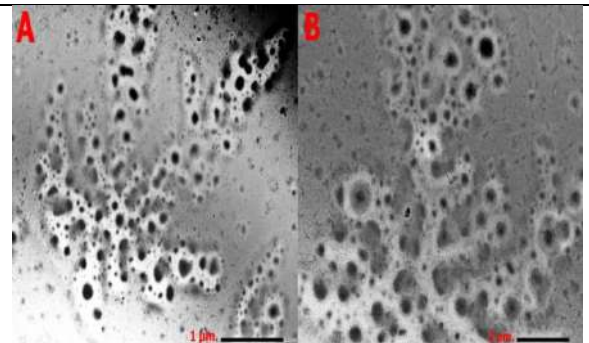


Figure.4.TEMimage of TXN/ZCS

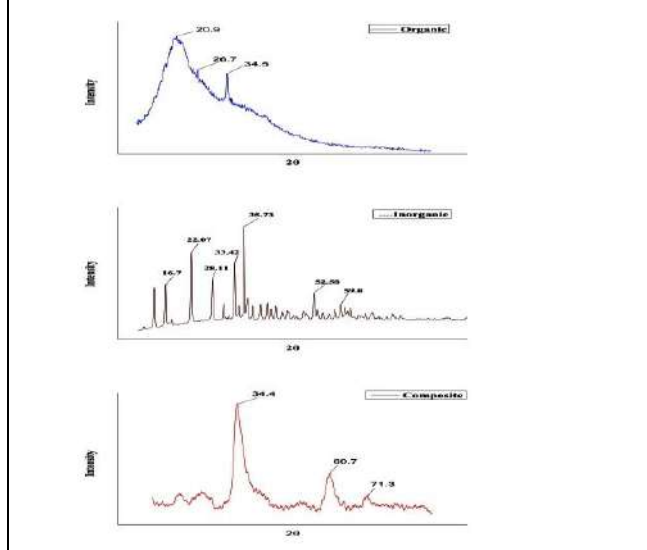


Figure.5. XRD graphs of a ZCS, b TXN and c TXN/ZCS

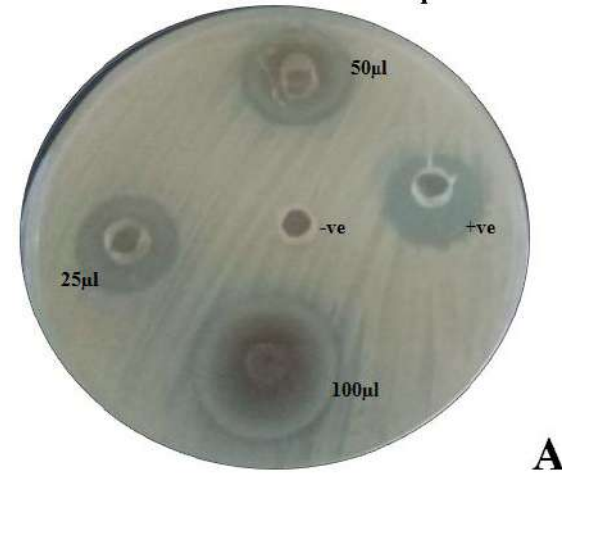


Figure.6. Antimicrobial activity of TXN/ZCS against A) *Salmonella Typhi*

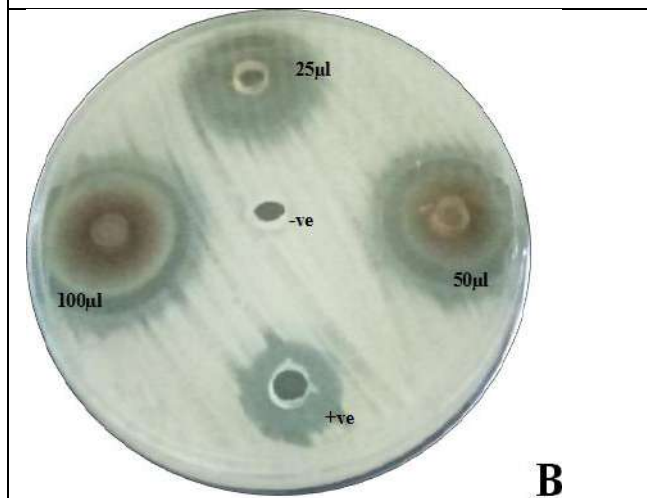


Figure.6. Antimicrobial activity of TXN/ZCS against B) *Bacillus subtilis*.

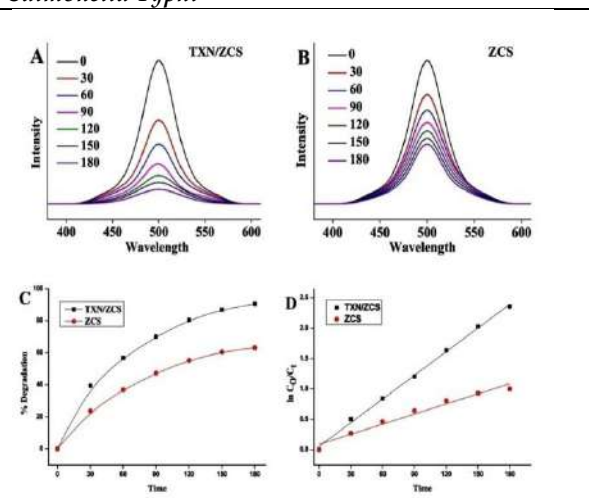


Fig. 7 UV spectra of a TXN/ZCS, b ZCS with RSL ; c% degradation of TXN/ZCS, ZSPT with time (RSL),dpseudo first-order kinetics with RSL.





Nirantak Kumar et al.,

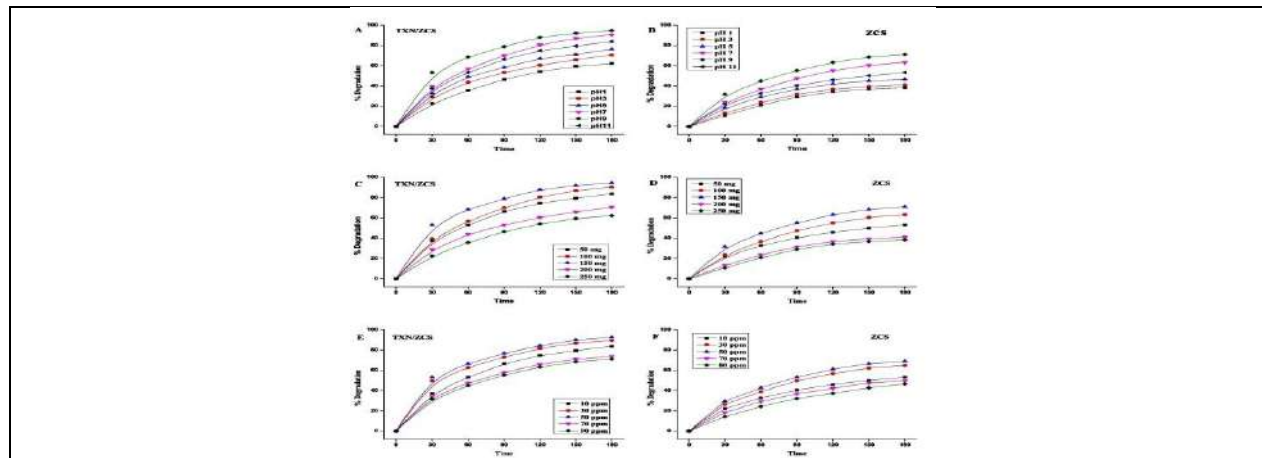


Fig. 8 Effect of pH on % degradation of a TXN/ZCS and b ZCS with RSL. Effect of catalyst loading on % degradation of RSL with c TXN/ZCS dZCS. Effect of concentration of RSL on % degradation of e TXN/ZCS and f ZCS





## Utility of Phenolic Acids and Bio molecules in *Moringa oleifera* plant Extracts for the Synthesis of Metallic Nanoparticles and their Applications: A Review

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### ABSTRACT

*M. olifera* (commonly known as “miracle tree *Moringa oleifera*”) is a medicinal plant of Moringaceae family and highly advantageous for human health because of their efficacy as neuro-modulators, immune-stimulators and antioxidants. A variety of phyto chemicals as phenolic acids and bio molecules (eugenol, naringnin, apigenin, kaempferol, quercetin etc.) are reported In extract of *M. oleifera* leaf. Due to the presence these phyto chemical constituents, the extract of *M. oleifera* plant parts is significantly useful for the economic and eco-friendly synthesis of various single and bi-metallic nano particles (NPs). The developed NPs by this economic approach exhibited excellent utility in anticancer, antimicrobial activity and water remediation applications as photo catalyst. This review study summarizes the recent progress in synthesis of metallic NPs using phyto chemical constituents of *M. oleifera* plant along with their potential application in various scientific domains including anticancer and antibacterial properties.

**Keywords:** *Moringa Oleifera*; Phyto chemicals; Photo catalytic degradation; Anticancer, Antibacterial efficacy





Amit Bhardwaj and Arun K. Singh

## INTRODUCTION

*Moringa oleifera* (*M. oleifera*) belonging to the Moringaceae family and known as an edible and ayurvedic herb because of its various nutritional and health advance features. In addition, due to the hairy stems, *M. oleifera* is commonly called as “miracle tree” [1–5]. Extract of this plant are highly useful against various infection arises from bacteria, fungi, protozoa and viruses [3–5]. Bark is smooth, dull dim in shading and pale yellow in colour. Twigs and shoots are short yet bristly hairy. Crown is wide open umbrella shaped. It has been reported that *M. oleifera* plant is significant enriched with high content of phenolic compounds, mostly flavonoids, phenolic acids and their glycosides. It also like saponins, tannins, terpenoids, beta-carotene, vitamin C, vitamin E, and poly phenols [1,6]. Polyphenols content of *M. oleifera* leaves has been a strong antioxidant effect against free radicals and decrease impacts of oxidative stress (OS) [2,7–10]. Mumtaz et al., [5], and Gopi et al., [11] reported the presence of various phenolic compounds via the solvent extraction study of *M. oleifera* leaves using n-hexane, chloroform, ethyl acetate, butanol and aqueous solvents (Fig. 1). *M. oleifera* plant have medicinal properties, which includes renal protective, hepato protective, neuro protective, antioxidant, anti-inflammatory, anti-carcinogenic, antimicrobial, and immune-improving activities. Renal Protecting property of *M. oleifera* can be seen in case of heavy metal toxicity via regulation of renal functions and prevention of oxidative damage as well as inflammatory reactions [1]. *M. oleifera* can also cure various types of chronic diseases. *M. oleifera* leaves, has been utilized for curing anxiety, stress and pain, asthma, fever, wounds, anti-diabetes activities [2,12], neurological problems, cancer treatment, and, kidney stone formation [12], antimicrobial, anti-inflammatory and anti-cancer.

In addition to the various medicinal applications, the *M. oleifera* plant extract is highly useful in the synthesis of single and bimetallic NPs as an eco-friendly, inexpensive synthesis approach such as silver NPs [13], zinc oxide NPs [14], magnetite NPs [15], MgO NPs [16], titanium dioxide NPs [17], and selenium NPs [18]. The above reported phyto chemical constituents of *M. oleifera* plant extract are reported as excellent reducing and capping agents which offer significant advantages to prepare stabilized metallic NPs. *M. oleifera* plant extract mediated synthesized NPs are highly useful in various environmental, energy storage and medical applications including anti-cancer, anti-bacterial, and photo catalytic degradation of organic contaminants from aqueous media. For instance, Se NPs have been reported for antibacterial potential [10], nephro toxicity [2], antiurolithiatic activity and antimicrobial activity against pathogens [10], ZnO/Ag NPs displays anticancer activity [19]. La<sub>2</sub>O<sub>3</sub> NPs has been utilized for drug delivery applications for the tested pathogens [20], ZnO/Ag NPs synthesis and their anticancer activity [19], AuNPs exhibited antioxidant, anti diabetic and anticancer activities [21]. CeO<sub>2</sub> NPs exhibit a high antimicrobial activity in the range of 15-31 mm zone inhibition [22]. RGO/V<sub>2</sub>O<sub>5</sub> electrode indicates the suitability of the material in the field of energy storage [23], Ni/Fe<sub>3</sub>O<sub>4</sub> *M. oleifera* leaf extract NPs is an efficient catalyst for the degradation of Malachite green [24]. In this review study, we have summarized recent advances in the preparation of various metallic NPs with the utilization of *M. oleifera* plant extracts. The process of nano particle synthesis and their applications are clearly discussed along with scientific explanations. In addition, shortcoming behind this green synthesis approach for large scale nano particle synthesis and future prospects are also discussed.

### Synthesis of metallic NPs using extract of *M. oleifera*.

In this section, biogenic synthesis of single and bi-metallic NPs is discussed along with their environmental and medical applications. In addition, approved methodologies and techniques involved in nanoparticle synthesis are also insight in detail along with statement of NPs applications. Tumbelaka *et al.* [25] reported, to synthesized Fe<sub>3</sub>O<sub>4</sub>/TiO<sub>2</sub> NPs and their applications in photo catalytic degradation. The *M. oleifera* leaf was heated in distilled water at 60 °C. A dark-greenish solution was formed after stirring for one hour and then was cooled at room temperature. The filtration process was continued using Whatman 01 paper, in Fig. 1(a). Author firstly, took 4.054 g of FeCl<sub>3</sub>·6 H<sub>2</sub>O and 2.086 g of FeSO<sub>4</sub>·7 H<sub>2</sub>O (Fig. 1(b)) and were dissolved in distilled water and stirred for a few minutes. While stirring at 600 rpm, the *M. oleifera* solution was added to the Fe<sub>3</sub>O<sub>4</sub> solution. In addition, 10% ammonia solution was added and then the solution was stirred for 90 min. The nanoparticles were next magnetically separated; the precipitated Fe<sub>3</sub>O<sub>4</sub> NPs were then dried for two hours at 100 °C. NPs were prepared using the same method used for







## Amit Bhardwaj and Arun K. Singh

$\text{Fe}_3\text{O}_4$  (Fig. 1(c)).  $\text{Fe}_3\text{O}_4$  was dissolved in 10 mL of ethanol and ultra sonicated for 30 min. The  $\text{Fe}_3\text{O}_4$  solution was mixed with 30% TTIP solution while stirring at 800 rpm for one hour at room temperature. Acetic acid was added until a pH of 2 was achieved. The solution was washed several times with distilled water and the precipitate was separated with an external magnet. Finally, the precipitate was dried in a furnace at 100 °C for two hours. The coprecipitation method was used for green synthesis of photo catalyst  $\text{Fe}_3\text{O}_4/\text{TiO}_2$  NPs with  $\text{Fe}_3\text{O}_4/\text{TiO}_2$  concentrations of 3:1, 1:1, 1:3, 1:5, and 1:7. The EDX Spectrum showed the existence of elements O, Ti, and Fe confirms the formation of  $\text{Fe}_3\text{O}_4/\text{TiO}_2$  NPs. From X-ray diffraction and selected area electron diffraction it was observed that  $\text{TiO}_2$  has a tetragonal structure and  $\text{Fe}_3\text{O}_4$  has an inverse spinel cubic structure. Fourier-transform infrared spectra showed functional groups namely –H, C–O, C–C, and C–N which indicating successful green synthesis. A vibrating sample magnetometer displayed that  $\text{Fe}_3\text{O}_4/\text{TiO}_2$  NPs exhibited saturation magnetization in the range of 11.15–30.38 emu/g, with a coercivity value of approximately 55 Oe. The degradation efficiency of methylene blue was optimal for  $\text{Fe}_3\text{O}_4:\text{TiO}_2$  at a concentration of 1:7 which reached 99.9% degradation for two hours for uptake every 20 min. NPs could be recycled up to four times due to their magnetic properties. The study concluded that  $\text{Fe}_3\text{O}_4/\text{TiO}_2$  NPs can be proved economical in treating of organic pollutant. Matinise *et al.* [26] reported, to synthesize  $\text{ZnZrO}_3$  nanocomposites by *M. oleifera* plant extract. 30 g of cleaned *M. oleifera* leaves were immersed into 300 mL of boiled deionized water. The mixture was heated for 1 hour 45 min. at 50 °C under magnetic stirrer. Then the mixture was cooled at room temperature and filtered through a Millipore filter. Author's another study.  $\text{ZnZrO}_3$  nano composites, weight 5.0 g of zinc nitrate and zirconium nitrate were dissolved into 50 mL of *M. oleifera* extract under magnetic stirring for one hour.

The foil was used to cover the solution for 18 hours. After the appearance changes in colour no precipitation formed. Then, dried the solution in a standard oven at 100 °C and washed with distilled water to remove the reductant materials of the extract. The sample was annealed at different temperature (500 and 700 °C) for two hours Identification of Structural, morphological and optical characters of the nano composites were studied by XRD, HRTEM, FTIR and PL. XRD analyses revealed pure and polycrystalline face-center cubic structure of  $\text{ZnZrO}_3$  nano composite. Electrochemical properties of the nano composites were characterized by cyclic voltammetry and electrochemical impedance spectroscopy using NaOH as an electrolyte.  $\text{ZnZrO}_3$  nano composites demonstrated high electrochemical activity. To accomplish  $\text{ZnZrO}_3$  nanocomposites can be utilized for electrochemical applications due to good voltametric response, high electro-activity and good electrochemical kinetics. Kayathiri *et al.* [27] reported, to synthesized  $\text{BaZrO}_3$  NPs through *M. oleifera* leaf extract. Total weight of 25 g *M. oleifera* (Drumstick) leaves were washed with de-ionized water, dried, crushed into powder and dissolved in 25 mL de-ionized water, 5 mL ethanol and kept in soxhlet apparatus maintained the temperature at 60 °C for two hours. After that filtration was performed using Whatman No.1 filter paper. Author synthesized  $\text{BaZrO}_3$ , barium chloride and zirconium oxychloride 0.1 M of each were dissolved in 140 mL de-ionized water and 10 mL liquid ammonia. After stirring for 30 min the solution was kept undisturbed for two hours to form precipitates which were washed, calcined at 400 °C for one hour and crushed to form  $\text{BaZrO}_3$  NPs. The use of liquid ammonia as precipitating agent has been avoided when *M. oleifera* leaf extract is used. So that the toxicity involved with ammonia was avoided when  $\text{BaZrO}_3$  NPs are green synthesized.

The synthesized  $\text{BaZrO}_3$  NPs were heated at 200 °C for one hour to avoid agglomeration and to maintain uniform grain size. The complete procedures adapted to green synthesize  $\text{BaZrO}_3$  NPs using leaf extract is shown in Stages I and II of (Fig. 2). In another study, characterization by X-ray diffract to grams revealed cubic nature of the samples with (110) preferential growth. XPS studies confirmed the presence Ba, Zr and O.  $\text{BaZrO}_3$  NPs exhibited antimicrobial property against *E. coli* and *A. terreus*.  $\text{BaZrO}_3$  NPs exhibited degradation property of 84.1% after 90 min against CR dye. and it seems to be well suited for practical applications as potential dye deactivator under UV light. Merugu *et al.* [28] reported, to synthesize bimetallic silver and copper NPs from *M. oleifera* (drumstick) fruit pulp aqueous extracts and their antimicrobial activity was tested. *M. oleifera* (Drumstick) fruits extract is used with Milli-Q water. Drumstick fruit aqueous extracts were filtered and 40 mg each of silver nitrate and copper acetate was dissolved and incubated for 24 hours at 70 °C. The silver and copper NPs containing fruit pulp aqueous extract solution was centrifuged and washed with Milli-Q water. The samples were then subjected to different analytical techniques for



**Amit Bhardwaj and Arun K. Singh**

characterization. FTIR, Raman spectroscopy, SEM and TEM showed the functional groups, morphology and size. EDAX was used for confirmation of the chemical composition. Antimicrobial activity was tested through disc diffusion method. The bimetallic NPs were 9 nm in size. The NPs inhibited pathogenic bacteria as compared with Ampicillin. Antimicrobial property was observed in NPs so that these can be used in preparation of antibacterial drugs. Preethi et al., [10] reported, to synthesize 20% Ag-doped CuO NPs. 10.0 g of *M. oleifera* leaves in powdered form were dissolved in 100 mL of double distilled water and kept boiling at 80 °C for two hours. 5.0 mL of *M. oleifera* leaf extract was obtained. The solution color was changed to light brown and stored at -4 °C for further usage. In another work 0.5M of CuCl<sub>2</sub>. H<sub>2</sub>O was dissolved in 50 ml of double distilled water and then added 5.0 mL of prepared leaf extract. Complete reaction mixture was kept in stable pH and the solution was continuously stirred for 2-3 hours. The final product was filtered and dried at 150 °C in the furnace. Author for synthesizing 20% Ag-doped CuO NPs, took appropriate quantity of AgNO<sub>3</sub> and CuCl<sub>2</sub>. H<sub>2</sub>O was added to it, and followed the similar procedure. The Pure and 20% Ag-doped CuO NPs have been successfully prepared by a green agent like *M. oleifera* leaf extract is shown in Fig. 3. X-ray Diffraction, displayed the monoclinic structure, the average crystallite size for pure and 20% Ag-doped CuO NPs were found to be 15.22 nm and 3.67 nm. The surface morphology of the specimens was analyzed by FE-SEM and TEM. FE-SEM images depicted the nanostructures for pure and 20% Ag-doped CuO NPs. The average particle size obtained for the NPs from FE-SEM was found to be in the range of 12.84 nm-14.52 nm & 2.55 nm-5.04 nm was in good agreement with the average crystallite size from XRD results. TEM images displayed that CuO NPs were distributed uniformly and for 20% Ag-doped CuO NPs, Ag NPs adhered on the surface of CuO NPs, EDAX spectra indicated that the peaks were corresponding to Cu, O, and Ag elements.

The presence of functional groups was identified by Fourier Transform Infrared Spectrometer (FT-IR). The stability of the NPs was confirmed by zeta potential analysis. The negative potential value of -34.23 mV and -36.12 mV for green synthesized NPs were identified. The green synthesized CuO NPs exhibited growth inhibitory activity towards microbes but while increasing the (20%) concentration of silver (Ag) as a dopant it showed excellent results towards antimicrobial activity. With an increase in the concentration of NPs, the weight of the formed crystal was gradually reduced for control to pure from 2.67g to 0.51g and for 20% Ag-doped CuO from 2.67g to 0.36g at 5% concentration. The inhibitory effect of synthesized 20% Ag-doped CuO NPs showed a percentage of inhibition of 86.95% as compared with pure CuO showed 81.52% at a 5% concentration. Maximum inhibition was observed for 20% Ag doped CuO NPs against bacterial pathogens such as *S. aureus*, *Bacillus subtilis*, and *Escherichia coli* (8mm) in diameter and fungal *Candida albicans* (6mm) in diameter. This encouraged the creation of ammonium magnesium phosphate hexahydrate crystals and a reduction in the nucleation rate of urinary tract infection-causing struvite stones. To conclude the beneficial impact of green synthesized pure and 20% Ag doped CuO NPs can be considered as ideal for environmental, biomedical, and pharmaceutical applications.

Rafique et al. [19] reported, synthesis of zinc oxide/silver NPs (ZnO/Ag NPs) using three different plant extracts. The plants were used *M. oleifera*, *Mentha piperita*, and *Citrus lemon*. 20 g of *M. oleifera* leaves, *Citrus lemon* peels, and *Mentha piperita* leaves were sliced into tiny pieces and boiled in distilled water with constantly stirring. Optimum time duration ranges from 40 to 80 min at temperatures from 40 to 80 °C as given in Fig. 4 (a). later the extract was filtered and stored at 10 °C for further process. In another work, 0.9 M zinc acetate dihydrate solution was prepared in DW and 0.1 M silver nitrate solution was prepared in DW, 10 mL of plant extract *M. oleifera*, *Mentha piperita*, and *Citrus lemon* was added to the combined solution of zinc acetate dehydrate and silver nitrate as shown in Fig. 4 (b). The solution was kept on the magnetic stirrer for ~70 min at 70 °C and with a stirring rate of ~1200 rpm. After ~70 min a colloidal type solution was obtained. The solution was centrifuged and composite powdered form was obtained at the bottom of the centrifuge tube. After filtration the precipitates were washed the by distilled water. The composite powder was then dried at a temperature of 70 °C for 24 hours in an oven. The same co-precipitation method was adopted for the synthesis of Ag, and ZnO NPs using *M. oleifera* plant extracts. Fig. 4 (c) provides a potential reaction route for the synthesis of ZnO/Ag using *M. oleifera*, *Mentha piperita*, and *Citrus lemon*, where functional components of plant extracts ligate with zinc, a silver pioneer. The extract contained flavonoids that acted as ligands and had the unique capacity to chelate different metal ions, which promotes ion reduction and subsequent stability of the ions to their nano form. As mentioned through equations (Fig. 4(c)) zinc acetate and silver nitrate dissolved in water to form



**Amit Bhardwaj and Arun K. Singh**

freely moving ions. The free ions targeted the phenolic compound's active sites in the extract, for stability and reduced it to its nano form. Reduction process contributed "OH" functional groups in phyto chemicals. Hydroxyl aromatic ring groups interacted with zinc and silver ions to form complex ligands. When the organic solvent mixture was heated it resulted in the formation of ZnO/Ag NPs. Characterization of was performed through UV vis, XRD, FESEM, EDX, and FTIR techniques. ZnO/Ag NPs exhibited narrow size having an average particle size upto  $119 \pm 36$  nm. Silver NPs, zinc oxide NPs and ZnO/Ag NPs synthesized with *M. oleifera* have anticancer property against human cervical cancer cells (HeLa). It was found that ZnO/Ag NPs demonstrated in vitro cell viability of 72%, 81%, and 84% using 2.5, 5, and 10  $\mu\text{g l}^{-1}$  of ZnO/Ag NPs for 24 h. Whereas Ag NPs and ZnO NPs prepared through *M. oleifera* displayed 50% and 60% cell viability using 2.5  $\mu\text{g l}^{-1}$  concentration for 24 h. ZnO/Ag NPs was found to exhibit strong anticancer agents as compared to Ag NPs and ZnO NPs. The MTT assay and the HeLa cancer cell line were used to assess the cell cytotoxicity and validate the anticancer activity of the green synthesized ZnO NPs, Ag NPs, and ZnO/Ag NPs using *Moringa oleifera*. Synergism between ZnO and Ag occurred, so that the composite material exhibited greater in vitro anticancer activity toward human cervical cells. It was revealed that the aqueous *M. oleifera* extract stabilized synergistic ZnO/Ag NPs have their applications in biomedical research and innovation. Prasad et al.,[24] reported, a low-cost and ecofriendly method for synthesis of nickel supported iron oxide magnetic NPs (Ni/Fe<sub>3</sub>O<sub>4</sub> MNPs) from *M. oleifera* leaves extract as reducing and capping agent. 20 g *M. oleifera* leaves were dried and powdered and then refluxed at 80 °C with 100 mL of de-ionized water for two hours.

Then the mixture was allowed to cool to room temperature. Aqueous extract was centrifuged at 8000 rpm was obtained through filtration. The filtrate was stored at 4 °C for further processes. In another work, Author prepared green synthesis of Ni supported on magnetite nano catalyst, weight 0.5 g of FeCl<sub>3</sub> · 6H<sub>2</sub>O and 0.1 g of NiCl<sub>2</sub> · 6H<sub>2</sub>O were dissolved in 30 mL aqueous extract of the leaves *M. oleifera* at 70 °C under dynamic stirring. Then, added drop wise a solution of 1.0 M Na<sub>2</sub>CO<sub>3</sub> to the mixture to obtain alkaline pH ~10, which caused changing the color of the solution. After continues stirring for three hours, a suspension was formed which gave precipitate of Ni/Fe<sub>3</sub>O<sub>4</sub> *M. oleifera* NPs following the centrifugation at 8000 rpm and the obtained NPs were rinsed with ethanol and distilled water and then dried at 60 °C for 12 h. The as-synthesized Ni/Fe<sub>3</sub>O<sub>4</sub> nano composite was characterized by various physicochemical characterization techniques such as FTIR, powder XRD, XPS, TEM and BET sorption methods. The results show that the Ni/Fe<sub>3</sub>O<sub>4</sub> *M. oleifera* NPs were exhibits spherical in shape with the size range of 16-20 nm. At room temperature, magnetic measurements of composite clearly evince ferromagnetic natures with saturation magnetization (Ms) of 76.8 emu/g. The XPS results show that the presence of Fe, Ni and O elements in the nano composite. And also, the percentage calculation of Fe and O elements in the composite sample shows about 15.42 (Fe 2p<sub>3/2</sub>), 13.23 (Fe 2p<sub>1/2</sub>) and 28.82% (O1s), respectively. The catalytic activity of Ni/Fe<sub>3</sub>O<sub>4</sub> *M. oleifera* NPs as a novel magnetic adsorbent for the removal of Malachite green from aqueous solution was determined by UV-vis spectroscopy. The binding of nickel onto the surface of magnetic Fe<sub>3</sub>O<sub>4</sub> NPs are confirmed by various microscopic and spectroscopic techniques. Furthermore, Ni/Fe<sub>3</sub>O<sub>4</sub> *M. oleifera* NPs shows strong catalytic activity towards MG dye degradation.

The significant advantages of this methodology are short reaction time, mild reaction conditions and elimination of hazardous materials. Raj et al.[23] synthesized RGO/V<sub>2</sub>O<sub>5</sub> nanocomposite by boiling 50 g of fresh, wash and dry *M. oleifera* plant leaves in 500 mL of DI water for 60 min in an Erlenmeyer flask. After 60 min. extract was filtered out by Whatman filter paper. The extract was stored in an airtight container for 4 hour and utilized as a reducing agent. In another work, firstly made 9:3 a mixture of H<sub>2</sub>SO<sub>4</sub> and H<sub>3</sub>PO<sub>4</sub> and a second mixture of graphite/KMnO<sub>4</sub> with a mass ratio of 2:6 was made. To avoid a vigorous reaction, the acid mixture was slowly poured into the beaker containing the graphite-KMnO<sub>4</sub> mixture in an ice bath at a temperature of 5 to 10 °C. The solution was kept at a constant temperature of 60 °C in a water bath. The solution was withdrawn from the water bath and mixed with 400 mL distilled cold water at end of the reaction. Then after, 5 mL of H<sub>2</sub>O<sub>2</sub> was added dropwise, resulting in a yellowish-colored solution. The addition of H<sub>2</sub>O<sub>2</sub> was intended to terminate the oxidation reaction by reacting directly with the excess potassium permanganate. The reaction product was rinsed four times with HCl aqueous solution and distilled water until it reached the appropriate pH. Added 10 mL *M. oleifera* leaf extract was combined with graphene oxide paste. For an hour, the mixture was heated while being stirred with a magnetic stirrer at 70 °C.



**Amit Bhardwaj and Arun K. Singh**

A stoichiometric amount of this solution was combined with Vanadium hydroxide precipitate, which is made by reacting sodium metavanadate with ammonium chloride in a 1:10 ratio. The black and foamy structure was moved to a stainless-steel container coated with Teflon and placed in a muffle furnace for two hours of hydrothermal treatment at 130 °C. After cooling, the solution was washed many times with DI water before being dried in an oven at 80 °C for four hours. After drying, the material was carefully crushed with a glass crusher and pestle and stored for future use. RGO/V<sub>2</sub>O<sub>5</sub> nano composite synthesis was given in Fig. 5. Analytical, spectroscopic, and electrochemical characterizations of synthesized V<sub>2</sub>O<sub>5</sub>, RGO, and RGO/V<sub>2</sub>O<sub>5</sub> nano composite were utilized to evaluate its morphology and structure. The RGO production and recombination with V<sub>2</sub>O<sub>5</sub> was confirmed by the Characterization, RGO. The process involved *M.oleifera* leaf extract followed by hydrothermal treatment. When compared to pure RGO and V<sub>2</sub>O<sub>5</sub> nano flakes, the RGO/V<sub>2</sub>O<sub>5</sub> nano composite exhibited improved electrochemical performance. The enhanced activity is due to the improved surface area and conductivity. RGO/V<sub>2</sub>O<sub>5</sub> nano composite displayed a good specific capacitance of 906 Fg<sup>-1</sup> at a scan rate of has been accomplished for RGO/V<sub>2</sub>O<sub>5</sub> nano composite at a scan rate of 2 mVs<sup>-1</sup>. Modified RGO/V<sub>2</sub>O<sub>5</sub> electrode exhibited good stability and can preserve roughly 83% of its initial capacitance even after 5000 cycles. The result of electrochemical performance of RGO/V<sub>2</sub>O<sub>5</sub> electrode indicated the suitability of the material in the field of energy storage. In addition to this, other single and bimetallic metallic nanoparticle synthesis from different metal precursor (with their properties and application) that have been examined in various studies in recent years are summarized in Table 1.

**CONCLUSION**

The major phyto chemicals e.g., alkaloids, flavonoid and polyphenolic derivatives found in the extract *M. oleifera* plant parts behave as reducing agent for restoration of precursor metal ions into NPs as well as also perform the function of capping/stabilizing agent in order to maintain the synthesized particles in nano range by the prevention of agglomeration. It is observed that *M. oleifera* plant extract is favorable for the synthesis of variety of single and bi-metallic NPs as an in-expensive and eco-friendly approach. The synthesized NPs exhibit excellent efficacy in various application including water remediation, energy storage, anti-cancer and anti-bacterial applications. Although *M. oleifera* extract favored green synthesis of metal NPs, there are distinct concerns as quantification of product yield with respect to utilized extracts of *M. oleifera* plant parts, reproducibility and consistency in shape and sizes of single and bimetallic NPs. The above discussed literature clearly inferred that the name of key phyto chemicals and their assessment in utilized volume of plant extract is still not very much clear and not optimized in a particular fixed parameters. Consequently, the recognition of key phyto chemicals as reducing, capping and stabilizing agents and their analysis are needed in the future research for the green synthesis of single or bi-metallic NPs with distinct characteristics and high yields.

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**Amit Bhardwaj and Arun K. Singh**

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**Amit Bhardwaj and Arun K. Singh**

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**Amit Bhardwaj and Arun K. Singh**

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**Table 1: Properties and application of some other metallic NPs from different metal precursor using phytochemical constituents of *M. Oleifera*.**

S.N.	Plant source	Nanoparticles	Approach	Characterization			Application	Ref.
				Particles size	Shape	Surface area		
1.	<i>M. oleifera</i> leaves	Zinc oxide NPs	Green method	15 nm	Semi-spherical	--	Biologically effective compound for mitigating acrylamides (ACR) neurotoxic and neurobehavioral effects.	[29]
2.	<i>M. oleifera</i> leaves	Zinc iron oxide (ZnFe <sub>2</sub> O <sub>4</sub> ) NPs.	Green chemistry method	10-25 nm	Spherical, cubic shape	--	ZnZrO <sub>3</sub> nanocomposites are a highly suitable for electrochemical applications	[30]
3.	Leaves of <i>M. oleifera</i> (M) & <i>Psidium guajava</i> (P)	Iron NPs (PMC-NPs)	Biosynthesis method	Average of 75-70, 76-2.0, and 82-7.0 nm	Hexagonal hematite structure	--	Antibacterial drugs, Photocatalytic degradation of MB dyes.	[31]
4.	<i>M. oleifera</i> fruit, <i>Moringa oleifera</i> leaves and <i>Terminalia bellirica</i> ,	Iron NPs	Biogenic methods	35–40 nm	Irregular shaped MOF-Fe and MOL-Fe	--	Antioxidant, antimicrobial and thermal properties	[32]
5.	Leaf and seed of <i>M. oleifera</i>	Iron NPs.	Green synthesis method	The size range 2.6 and 6.2 nm	Spherically shaped	--	Removal of nitrate ion (NO <sub>3</sub> <sup>-</sup> ) from surface and ground water and coagulant and antibacterial activities	[33]





## Amit Bhardwaj and Arun K. Singh

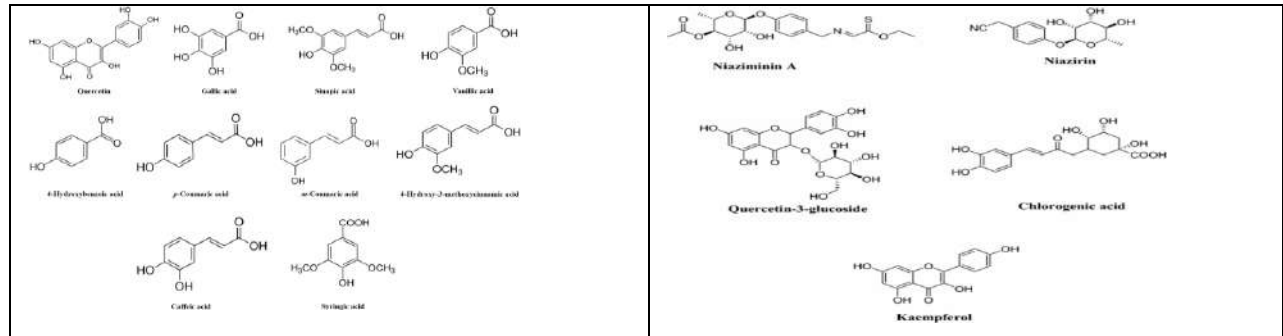
6.	<i>M. oleifera</i> stems and leaves	Se NPs	Green method	50-200 nm	--	--	Antibacterial activity against <i>L. monocytogenes</i> and <i>C. diphtheriae</i> in food and medical science.	[18]
7.	<i>M. oleifera</i> leaves	Se NPs	Green method	Average 3.2-20 nm	Spherical	--	Nephron-protective properties against MEL induced murine nephropathy.	[2]
8.	<i>M. oleifera</i> leaves	Nickel oxide NPs	Green method	9.69 nm	Nearly spherical	Large surface area	Cytotoxicity activity against human cancer cells and various zones of inhibition (mm). Antibacterial activity against various Gram positive and Gram-negative bacterial pathogens.	[34]
9.	<i>M. oleifera</i> leaves	Gold NPs	Green method	35–51 nm	Hexagonal shape	--	Biomedicine applications and environmental biological remediation	[21]
10.	<i>M. oleifera</i> leaves	La <sub>2</sub> O <sub>3</sub> NPs	Green method	52.049 nm, 73.482 nm, and 73.640 nm	Irregular cubic and rectangular shaped	--	Biological analysis (drug delivery applications)	[35]
11.	<i>M. oleifera</i> seeds	Silver NPs	Biogenic methods	4–32 nm	Fairy spherical-shaped	--	Ag NPs as excellent immobilizing agents and outstanding modulators of heavy metal induced toxicities	[36]
12.	Flower extract of <i>M. oleifera</i>	Hydroxyapatite nano-rods	Microwave assisted green	Mean particle size 41	Rod like structure	--	A very good antifungal activity against	[37]



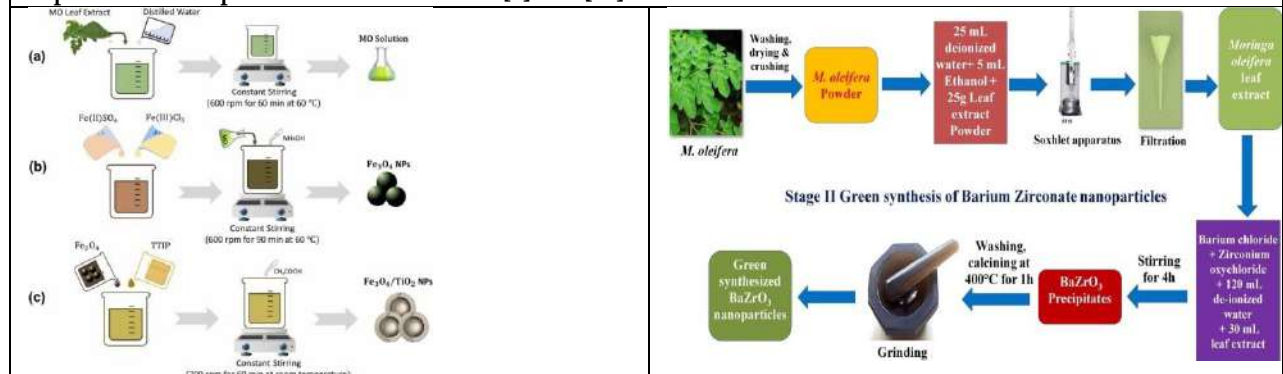


**Amit Bhardwaj and Arun K. Singh**

			synthesis	nm.			three common pathogenic fungi including; <i>Candida albicans</i> , <i>Aspergillus fumigatus</i> and <i>Aspergillus niger</i>
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**Fig 1: Schematic illustration of some common phyto chemical constituents presents in *M. oleifera* leaf extract. Reproduced with permission from Ref.Ref. [5] and [11].**



**Fig 2: Schematic illustration of the steps of preparation process for (a) *M. oleifera* solution, (b)  $Fe_3O_4$  NPs using the coprecipitation method, and (c)  $Fe_3O_4/TiO_2$  NPs using the coprecipitation approach. Reproduced with permission from Ref. [25]. Copyright, 2022, Elsevier.**

**Schematic illustration of synthesize  $BaZrO_3$  NPs using *M. oleifera* leaf extract along with combination of calcination process. Reproduced with permission from Ref. [27]. Copyright 2022, Elsevier.**





Amit Bhardwaj and Arun K. Singh

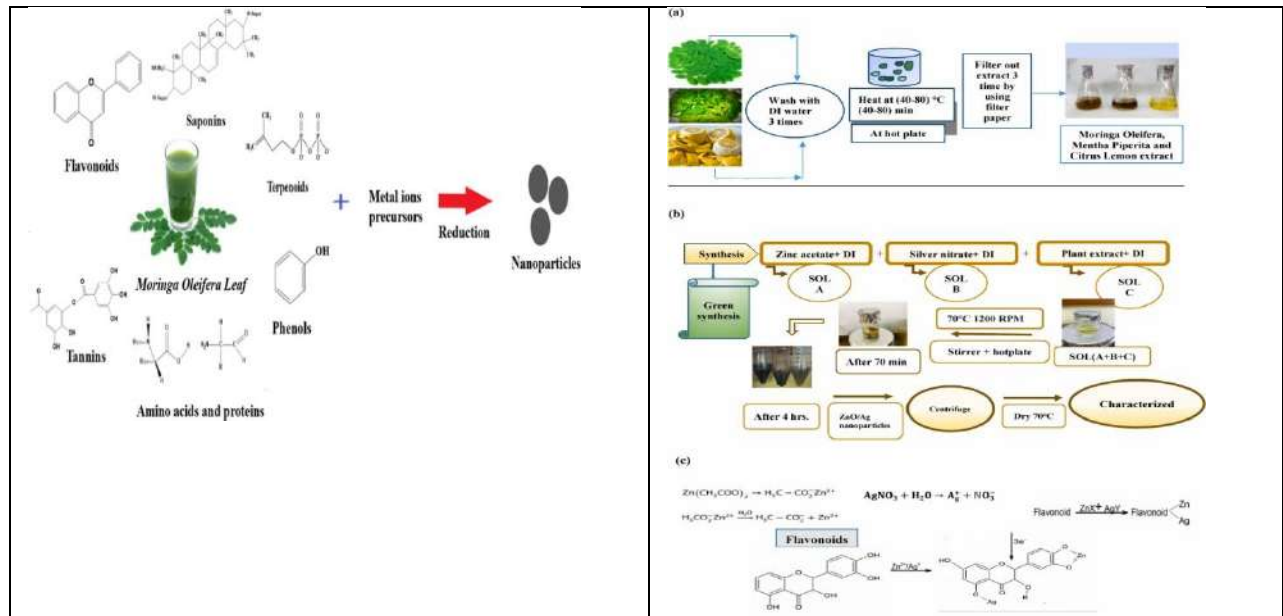


Fig. 3. Schematic illustration of the synthesis of 20% Ag-doped CuO NPs using plant extract. Reproduced with permission from Ref. [10]. Copyright 2022, Elsevier.

Fig. 4. Schematic illustration of a) synthesis protocol of three different plant extracts (i.e. *M. oleifera*, *Citrus lemon* and *Mentha piperita*) (b) plant extract mediated green synthesis of Ag/ZnO NPs (c) The chemical mechanism behind the process of ZnO/Ag nano article synthesis. Reproduced with permission from Ref. [19]. Copyright 2023, Elsevier.

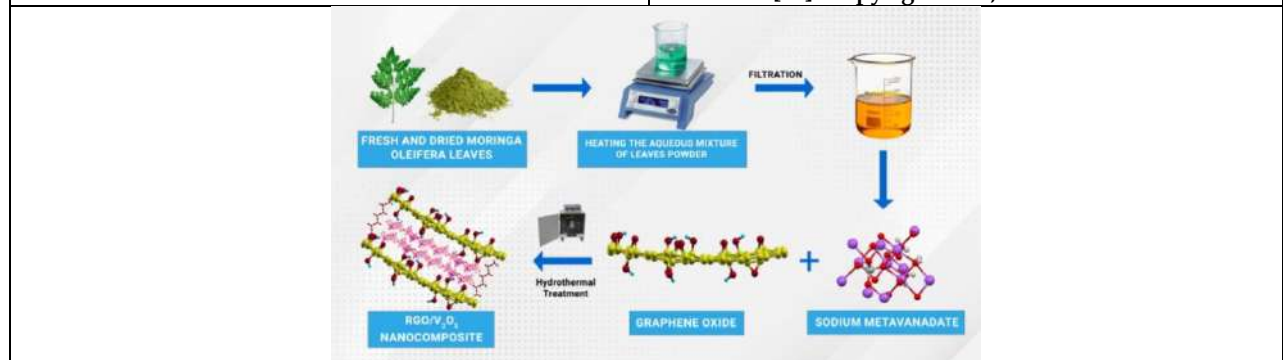


Fig. 5. Schematic illustration of green synthesis of nano composites of RGO/V<sub>2</sub>O<sub>5</sub> using plant extract and calcination process at a controlled temperature. Reproduced with permission from [23]. Copyright 2022, Elsevier.







# Reduced Graphene Oxide Supported Ni/Co- Based organic Frameworks for Visible Light Assisted Photo catalytic degradation of Methylene Blue

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## ABSTRACT

Bimetallic organic frameworks have become one of the most important raw constituents for the manufacturing of photocatalytic semiconductor materials. Herein, a newly developed reduced graphene oxide supported Ni/Co metals based organic frameworks (NCMR) nanocomposite was prepared using terephthalic acid via simple solvothermal method. The methylene blue (MB) dye was photo catalytically degraded using the produced nanocomposite. A variety of methods, including XRD, FE-SEM, UV-visible, BET-PSD, and FTIR were used to study the structural characteristics and morphology of synthesized nanocomposites. Results showed that NCMR exhibits exceptional photo degradation activity towards the MB dye and degrade it almost completely (99.8%) within 120 minutes of sunlight irradiation which is significantly higher than pure nanocomposite (Ni/Co-MOF) (74%). Furthermore, designed photo catalyst showed exceptional cyclic stability and retain almost 93.5% of initial degradation efficiency even after 5<sup>th</sup> cycle.

**Keywords:** Photocatalysis, Nanocomposite, Metal-organic framework, Dye degradation, Reduced graphene oxide.

## INTRODUCTION

Currently, industrial effluent holding diverse harmful compounds has resulted in substantial environmental degradation and drawn significant attention from academia and business. The volume of dye manufacturing in India is enormous, leaving behind a large amount of effluent. Dye effluent contains strong color, high levels of toxicity, intricate elements, and limited biodegradability, all of which are hazardous to the ecosystem and human health [1-2]. Furthermore, the procedure of dyes breakdown by natural processes is painstakingly slow. As a result, it



**Sonu Jakhar and Nirankar Singh**

is critical to use artificial ways to remove these harmful pigments from waste water. Methylene blue (MB) is a very common organic colorant which is found in high concentrations of effluent [3]. Physical adsorption, photo Fenton oxidation, advanced oxidation processes, and photocatalytic degradation are among the wastewater treatment technologies described in the literature [4, 5]. Photocatalytic degradation has been recognized as a potent wastewater treatment technique, attracting all over the globe, owing to its excellent qualities, green, and low cost [6]. In the last several years, metal-organic frameworks, or MOFs, have become more and more prominent in the field of photocatalysis [7]. MOFs are crystalline porous substances generated by the self-assembly of inorganic metal centers with bridged organic linkers [8]. MOFs offer several benefits over typical semiconductor photo catalytic materials, such as a high level of porosity, large surface areas, regular pore channels, changeable pore size, structural diversity, and tailor ability [9-11]. Although, single-metal MOFs have been effective in the photodegradation of organic contaminants during the past several years [12, 13]. However, because of the synergistic impact of the mixed metals, in a number of applications, multi-metal MOFs are said to outperform single-metal MOFs [14].

It is discovered that the semiconducting characteristics and stabilities of bimetallic MOFs are enhanced by their design. Sun et al. discovered, for instance, that MOF-74 (Co-Ni) exhibited greater catalytic activity for oxidizing cyclohexene when compared to pristine Co-MOF-74 [15]. Ye et al. demonstrated that Ni/Co-MOF displayed improved cyclic reusability and stability when catalytically oxidizing atrazine [16]. Building a hybrid photocatalytic setup may be thought of as a successful tactic to further increase photocatalytic performance. In recent years, it has been shown that combining RGO with MOFs can improve photocatalytic performance by increasing surface area, increasing visible light responsiveness, and separating photo induced pairs of electrons and holes [17]. Nevertheless, there hasn't been any research on combining RGO using dual metallic Co/Ni BDC MOFs to create hybrid photo catalysts that effectively degrade organic pollutants. In this work, a unique and incredibly effective hetero structure (NCMR) was created by decorating Co/Ni-MOFs (NCM) over RGO nano sheets using a one-step solvo thermal approach. The effectiveness of NCMR composites for MB's photocatalytic degradation was examined when exposed to visible light.

## MATERIALS AND METHODS

### Chemicals

NCMR was synthesized and characterized using analytical grade reagents and solvents provided by Central Drug House (P) Ltd. (India) without the need for further purification. Shilpent Enterprises (India) supplied research-grade RGO that was >99% pure and had a BET of >150 m<sup>2</sup>/g.

### Characterization Methods

Each sample was characterized by XRD (Panalytical's X'Pert Pro), FTIR (Perkin Elmer - Spectrum RX-IFTIR), and FESEM (ZEISS EVO 50). N<sub>2</sub> adsorption-desorption isotherms were evaluated with TristarII 3020 Micromeritics (at 77 K).

### Synthesis of NCM and NCMR

Co(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O (0.70 g), NiCl<sub>2</sub>·6H<sub>2</sub>O (1.04 g), and 1, 4-BDC (0.336 g) were combined in 55 mL of DMF and stirred until the mixture turned transparent. This translucent mixture was then heated to 120 °C for 18 hours using a 100 mL stainless steel reactor that had a Teflon lining. The precipitate was gathered and filtered away following the reactor's natural cooling. After many washes with 40 mL of DMF and 40 mL of methanol, solvent molecules and precipitate that hadn't yet reacted were eliminated. After that, the product was manually crushed to an extremely fine powder and let to dry overnight at 60 °C. Comparably, 100 mg of RGO was used in a reactor with comparable conditions to synthesize NCMR.



**Sonu Jakhar and Nirankar Singh****Evaluation of photodegradation activity**

A few samples of MB dye were used to test photodegradation efficiency of NCMR. The photocatalytic degradation was investigated using a 50 mL solution containing 20 mg/L MB dye and 30 mg/L catalyst. The first 20 minutes were spent for vigorously stirring the 50 mL dye solution in the dark without illumination. After that, the resulting combination was placed in intense sunlight, and the concentration of the dye (MB) was measured at various points throughout the photo degradation using a UV-Vis spectrophotometer (Lambda 750/NIR/PerkinElmer, USA). These tests were carried out using MB at room temperature (pH 5) and wavelengths of 664 nm.

**RESULTS AND DISCUSSION**

FESEM micrographs were used to study the morphologies of synthesized NCMR nanocomposite (Figure 1a-d). Fabricated MOF structure represents a spherical structure with an average diameter of 300 nm. Interestingly, owing to strong interaction with RGO, MOF particles were uniformly distributed over RGO sheets [18]. The PXRD patterns of NCM and NCMR are evaluated to study the crystal structure of materials (Figure 2). The (200) and (202) planes of NCM are associated with two unique wide diffraction peaks at  $2\theta = 9^\circ$  and  $2\theta = 15.7^\circ$ , respectively [19]. A broad peak corresponding to the (002) plane at  $2\theta = 25.7^\circ$  represents the presence of RGO and supports successful formation of NCMR nano composite [20]. The porous nature of created nano composites was evaluated by measuring their surface area using BET (Brunauer, Emmett and Teller) procedure and  $N_2$  adsorption-desorption isotherms (Figure 3). Interestingly, a large surface of  $104 \text{ m}^2/\text{g}$  was found by computing the BET-specific surface area for NCMR. Furthermore, synthesized photocatalysts exhibit hierarchical porosity with a large number of mesopores and micropores (inset Figure 3). The involvement of functional groups in the synthesis of MOFs was examined by FTIR studies. This is because the (-COO-) stretching vibrations are symmetrical and asymmetrical, the linker terephthalic acid exhibits two distinctive peaks at  $1682$  and  $1287 \text{ cm}^{-1}$  (Figure 4) [21]. In the case of NCMR synthesis, the peaks at  $1682$  and  $1287 \text{ cm}^{-1}$  are missing, indicating that the ligands are coordinated with metal centers. Furthermore, peaks at  $1590$  and  $1424 \text{ cm}^{-1}$  are seen in NCMR, which align with the flexible vibrations of the ligand's symmetric as well as asymmetric (-COO-) bonds that are coordinated to the metal centers [18]. The OH group vibrational stretching is responsible for the peaks located at  $3424 \text{ cm}^{-1}$  [22].

**Optical Properties**

Utilizing UV-vis spectroscopy is a viable method for understanding the optical properties of photocatalysts. The UV-vis spectra of pristine NCM and NCMR nanocomposites are shown in Figure 5a. When RGO is added, the absorption of NCMR nano composite shifts toward a more visible region, suggesting that RGO increases the ability of NCMR catalyst to absorb wider range of sunlight in visible region. It is therefore anticipated that the resultant nanocomposite photocatalysts would have apparent light-activated photocatalytic activity. The band gaps of the synthesized materials have been determined to be  $3.01 \text{ eV}$  for NCM and  $2.88 \text{ eV}$  for NCMR nano composites, respectively, using Tauc's equation (Figure 5b) [23].

**Photocatalytic properties**

The photocatalytic efficiency of synthesized materials was evaluated using a modal dye methylene blue (MB). Before photo degradation experiment the dye mixture was blended for twenty minutes in a dark medium. As represented in Figure 6, MB photodegradation was observed by a decrease in maximum absorption intensity corresponding to ( $\lambda_{\text{max}}=664 \text{ nm}$ ) in the UV-visible spectrum [24]. RGO supported material demonstrated almost 100% degradation of MB dye within 120 min of sunlight irradiation. However, only 74% dye was removed by catalyst without RGO under identical conditions. This is because, presence of RGO along with Ni/Co-MOF provide better charge separation, increase light absorption, reduce optical band gap as well as electron hole recombination. In addition to photocatalytic activity, reusability test for NCMR were investigated over the course of five runs. Interestingly, 93.5% of degradation was maintained even after 5<sup>th</sup> cycle (Figure 6c).



**Sonu Jakhar and Nirankar Singh**

## CONCLUSION

In summary, NCMR nanocomposite was successfully synthesized using simple solvo thermal technique. Designed nanocomposite displayed large specific surface area (104 m<sup>2</sup>/g) and lower optical band gap (2.88 eV). RGO provide a template for uniform decoration of bimetallic MOF over 2D graphene sheets. Exceptional qualities of RGO such as high surface area, better electron transport and synergistic effect with Ni/Co-MOF help in improving photodegradation activity of NCMR nano composite. Under 120 min of sunlight irradiation NCMR demonstrated 100% removal of organic dye (MB) which is significantly greater than pure Ni/Co-MOF (74%). Additionally, designed nano composite represents excellent cyclic reusability up to 5<sup>th</sup> consecutive cycle. The empirical findings showed that NCMR nano composite may be effectively used in wastewater treatment facilities to remove organic contaminants.

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Sonu Jakhar and Nirankar Singh

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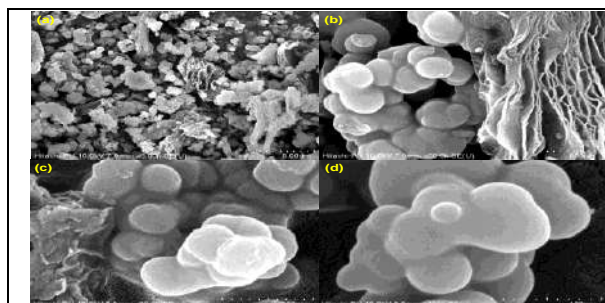


Figure 1:(a-d)FESEM pictures of NCMR

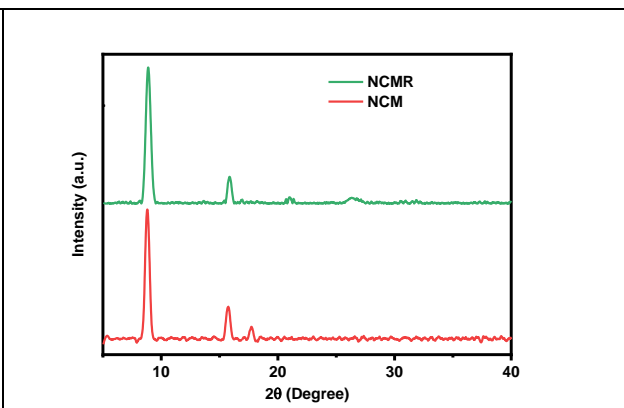


Figure 2: XRD diffraction Patterns of NCM and NCMR

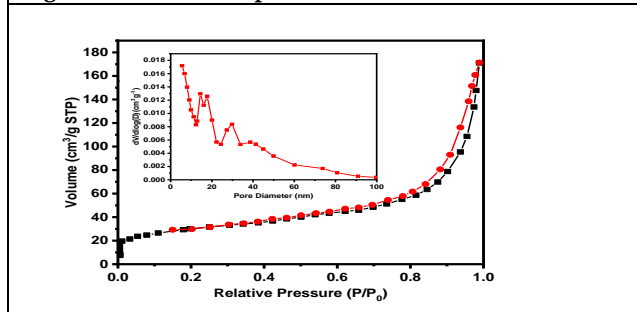


Figure 3:N<sub>2</sub> adsorption-desorption isotherms for NCMR(inset shows pore size distribution).

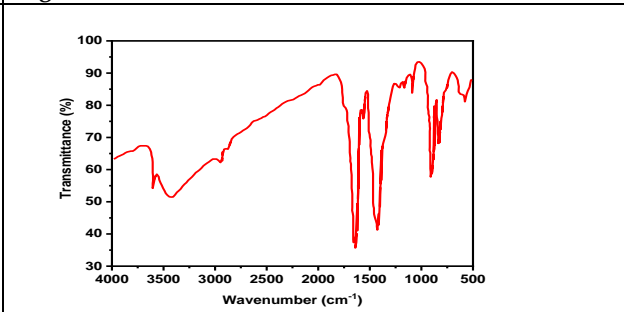


Figure 4: FTIR spectrum of NCMR







Sonu Jakhar and Nirankar Singh

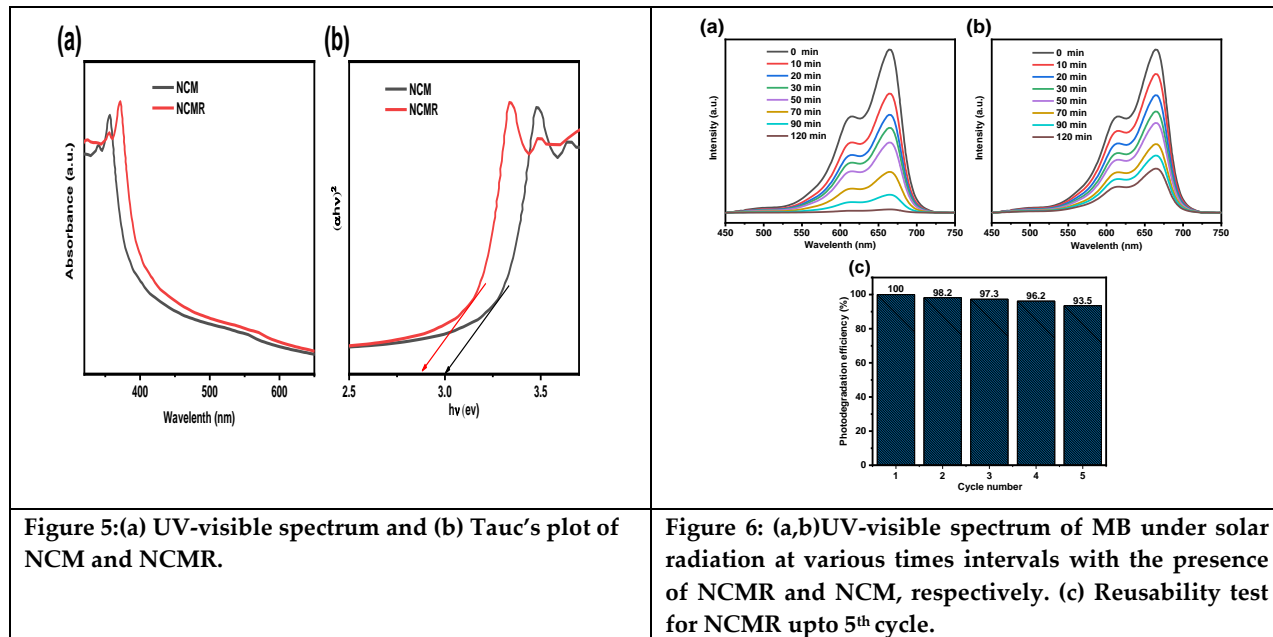


Figure 5:(a) UV-visible spectrum and (b) Tauc’s plot of NCM and NCMR.

Figure 6: (a,b)UV-visible spectrum of MB under solar radiation at various times intervals with the presence of NCMR and NCM, respectively. (c) Reusability test for NCMR upto 5<sup>th</sup> cycle.





## New Media and Romance Scam: A Study on the Mental Health of Victims

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### ABSTRACT

Dating is a sort of romantic association amongst humans, where the individuals personally or socially see each other, and spend some time together to understand others' behavior with an aim of evaluating each other's compatibility as a potential partner for the future. The practice of dating after the advent of new media has taken a different shape. The advancement of the internet gave birth and rise to a new age system of dating commonly termed "ONLINE DATING APPS". These apps seem to have a great impact on today's busy world, especially among youngsters. These platforms provide a base for both genders to get their desired partners to match their expectations. Apps such as Tinder, aisle, bumble, Ok Cupid, match.com, and many more are very famous among the mass, but as it is correctly said, everything has its own pros and cons, online dating apps has given birth to a new 21st-generation online disease that is netting the world rapidly called as " ONLINE ROMANCE SCAMS ". As the report of India TV shows that about 63 percent of social media users and 3 percent of the general population have been victims once, women, middle-aged people, romantic idealizations of affective relationships, and people with a higher tendency to anxiety are at a greater risk of a potential victim of such scams. The study aims to examine the new trend of these frauds, and how it is affecting the victims' life mentally and emotionally. The precautions to be kept in mind before using such apps, the mental health of the victim, after being scammed, and the nature and pattern of the scams being done, by examining survey results of five hundred correspondents from Jamshedpur (Jharkhand, India).

**Keywords:** Romance Scams, Online dating, Health Communication, New Media, Behaviour, Attitude.



**Amit Kumar Singh and Rahul Amin**

## INTRODUCTION

The market size of online dating sites has reached \$1 billion, and the sector's growth rate is impressive. In the recent decades, globalization, digitalization and modernization have significantly changed the face of Indian culture. Changes are occurring in all domains of the society, be it political, economic or social, or any vertical. Digitalization is not only advantageous it has multiple cons too, like the online frauds, which is not only alarming but a matter of huge concern. Humans have long understood the desire to develop romantic connections which initially starts with dating and "Dating" can be defined as "a dyadic relationship involving meeting for social interaction and joint activities with an implicit or explicit intention to continue the relationship until one or the other party terminates or until some other more committed relationship is established (e.g., cohabiting, engagement or marriage)" (Straus, 2004). Dating as "a dyadic interaction focuses on participation of mutually rewarding activities that may increase the likelihood of future interaction, emotional commitment, and/or sexual intimacy" (Sugarman and Hotaling 1989), but we have also realised that finding the right partner can be difficult. These sites offer services of access, communication and matching (Finkel et al, 2012). The rapid development of information and communication technologies (ICTs) and the prevalence of the internet offers an alternative venue for romantic endeavours (Rege 2009), One has access to more possible love partners through site membership than they would through traditional offline dating. Mathematical algorithms are used to establish compatibility between potential partners and provide matches based on a range of criteria (Valkenburg & Peter, 2007). The use of online dating services is so wide that Mitchell (2009) and Frost et al (2008) estimated that users spend up to twelve hours a week on online dating activity. Which has given birth to a newer version of romantic association called the "online dating" and it has resulted in the spike of crime the "Romance Scam". The online dating romance scam is an Advance Fee Fraud that is frequently carried out by global criminal organisations. (Despite the fact that it has also been shown that lone criminals participate in this illicit activity) via online dating sites and social networking sites. (Whitty & Buchanan, 2016).

According to the Online Dating Magazine founder Joe Tracy (2013), globally, there are over 8000 dating websites. Many online dating sites, including the top five sites globally, provide a mobile app-based version of their services for customers to access on their smart phones. A few popular dating websites are e-Harmony, OK Cupid, Zoosk, Match.com, and Plenty of Fish. Fraud committed online against individuals has become a global problem (Button, 2012; Levi, 2008; Smith, 2010). Very Few studies have been conducted on mass marketing fraud (Button et al., 2013; Levi, 2008). There are even very fewer research studies that address the psychological effects of this type of crimes on victims. If victims are to receive the right assistance and treatment and if present policing practises are to be improved when dealing with victims of this sort of crime, it is essential to understand the psychological damage. This article focuses on the online dating romance scam as one sort of mass-marketing fraud. This crime is being highlighted because it is so common, so unusual, and because it has the potential to result in a "double hit"—the loss of a relationship as well as a financial loss.

In these scams, the scammers create a fake account on the dating sites and social networking sites with someone else's photographs or morphed images. The criminals then initiate a relationship with an intention to defraud their prey with a hefty sum of money, with a different identity. While they simulate developing relationships with their victims, the end goal of the scammers is to defraud them. Before asking for money, the criminal puts the victim through a series of phases as their relationship evolves. The fraudster expresses their love for the victim at an early stage and requests that their relationship go from the dating site to messaging or telephonic communication, claiming that they want an exclusive connection with the victim. At this sensitive point of association, the criminal grooms the victim, primarily through the use of online media to establish a deep, personal contact with the victim. Over the course of weeks, months, or even years, communication is regular and intense. Phone conversations are also possible, but they are usually infrequent. Victims reveal personal information about them and form a trusting bond with the perpetrator. During the grooming stage, the prey usually falls for the predator. The fraud ends only when the victim learns they have been scammed and ceases to give money (Buchanan and Whitty, 2014 & Rege,



**Amit Kumar Singh and Rahul Amin**

2009). Once a large sum of money is deposited into the fraudster's account, the scammers' communication stops. The victim, who has never seen him or her physically but has created an imaginary small happy world with the fraudster, shatters emotionally, drifts into sadness, and loses his or her mental health and tranquillity.

Although the online dating and constant increase in romance scams are being reported these days, still the online dating sites and applications are propagating like anything. People are aware of these types of scams still, they are falling aperty. This study is exploratory in nature and aims to

- Study the mental health of the victim
- Explore the change in victims' attitude and behaviour.

**RESEARCH METHODOLOGY**

To study the behavioural and the changes in the attitude the researcher uses mixed research method which is a combination of both qualitative and quantitative approach. As defined by Creswell the mixed method is such one research method in which the researcher gathers, analyzes, and integrates both qualitative and quantitative figures in a single and multiple studies in a sustained program of inquiries (Creswell and Plano 2011). This method has the potential to extract substantial data for a conclusion through a convergence of findings. Secondly, through this method the scholar would be able to answer to a broader range of research queries, as the research is not confined to a single method. In conclusion, the mixed method approach can deliver materials and insights that might be missed if only a single method were used (Creswell and Plano 2011), both the methods will contain open-ended as well as closed-ended questions. Moreover, the use of qualitative and quantitative approaches in combination provides a better understanding of research problems than either approach alone (Creswell and Plano 2011). The researcher is aware of the mixed method approach's disadvantages, such as the time and effort required for the study, and the requirement that the researcher be proficient in both methods. Finally, data analysis might be challenging, especially if different methodologies produces different outcomes.

**METHOD-I SURVEY**

Survey method was used to acquire data from the target population; the researcher employed a questionnaire as a data gathering instrument for the survey data collection. The people aged between 18-30 were involved in the study of the universe as this age group uses the online dating application at large (Chakraborty 2019). The respondents are from the urban area of Jamshedpur, East-Singhbhum district of Jharkhand.

**SAMPLING DESIGN**

A sample design is a method for selecting a representative sample from a population. It refers to the method or procedure used by the researcher to pick things for the sample. Sample design may as well lay down the number of items to be included in the sample, the size of the sample. The sample design is determined before data are collected. (Kothari & Garg, 2014)

**SAMPLING TECHNIQUE**

In this investigation, basic random sampling was chosen as the sample technique. The researcher has chosen the urban neighbourhood of Jamshedpur. The responses and opinions of the respondents will be regarded as the views of the people of Jamshedpur. Even in the event of a huge population, the sample is more equally distributed throughout the population.

**FINDINGS OF THE SURVEY**

An online survey of 300 samples was conducted out of which 179 respondents have used the online dating mobile application and were defrauded.





**Amit Kumar Singh and Rahul Amin**

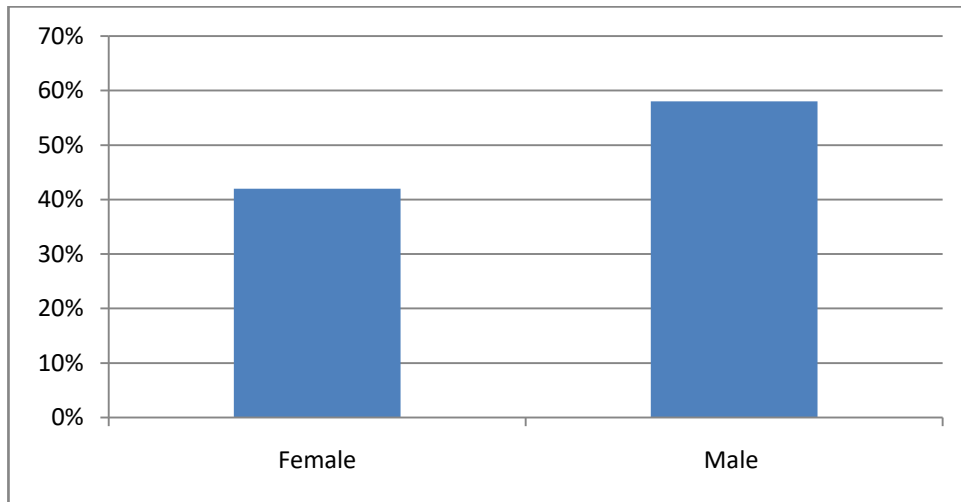


Fig 1: Percent of Female and male involved in the study

The graph shows that the female who has been defrauded by romance scams is 42 % whereas 58% of males using online dating mobile applications were at least once defrauded. All the respondents who have responded are unmarried.

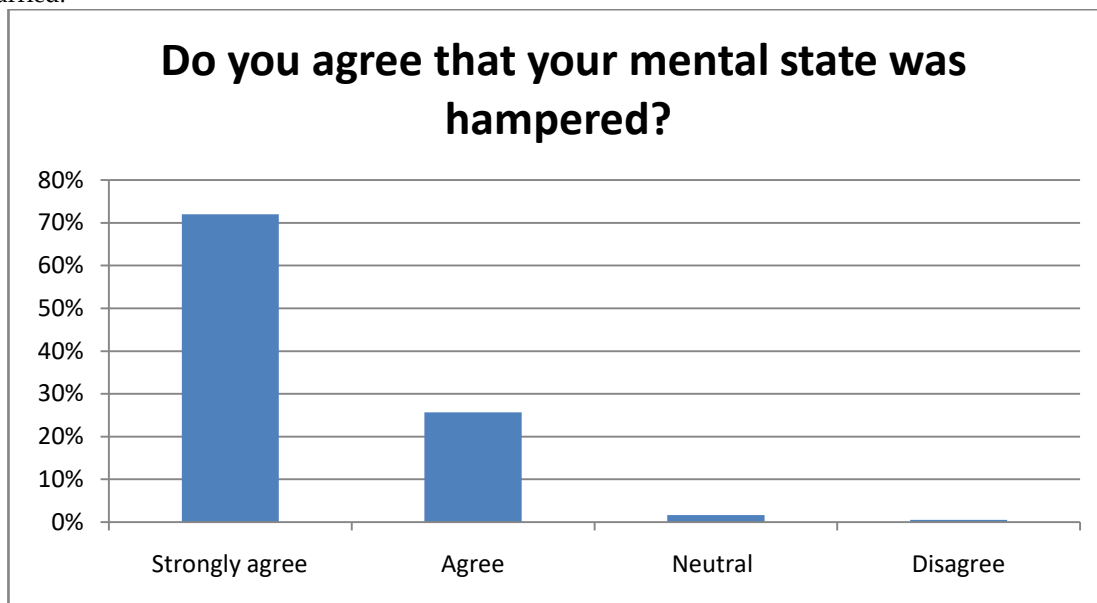


Fig 2: Shows the mental state of the victims

The graph shows the mental state of the victims after the scam. 72.06 % of the respondents strongly agreed that their mental state was precarious whereas close to 25.69 % agreed that they were mentally unstable. 1.68 % of respondents have a neutral opinion. And only 0.55 % of respondents showed their disagreement whereas none of the respondents strongly disagreed that their mental state was very unstable after the scam happened to them.







Amit Kumar Singh and Rahul Amin

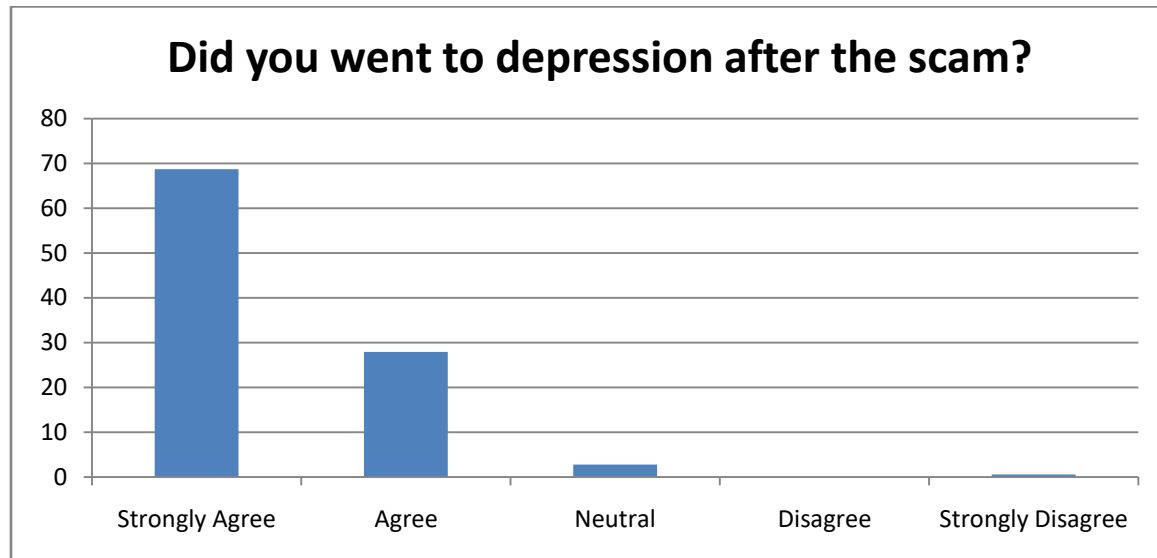


Fig 3: Shows the depression among the victims

The graphs in figure 3 show the depression among the victims. 68.72 % of the respondents strongly agreed that they were into depression after the scam. 27.93 % of the respondents agreed that they went into depression. 2.80 % of the respondents had a neutral view and only 0.55% strongly disagreed that they went into depression, whereas none disagreed that they were into depression.

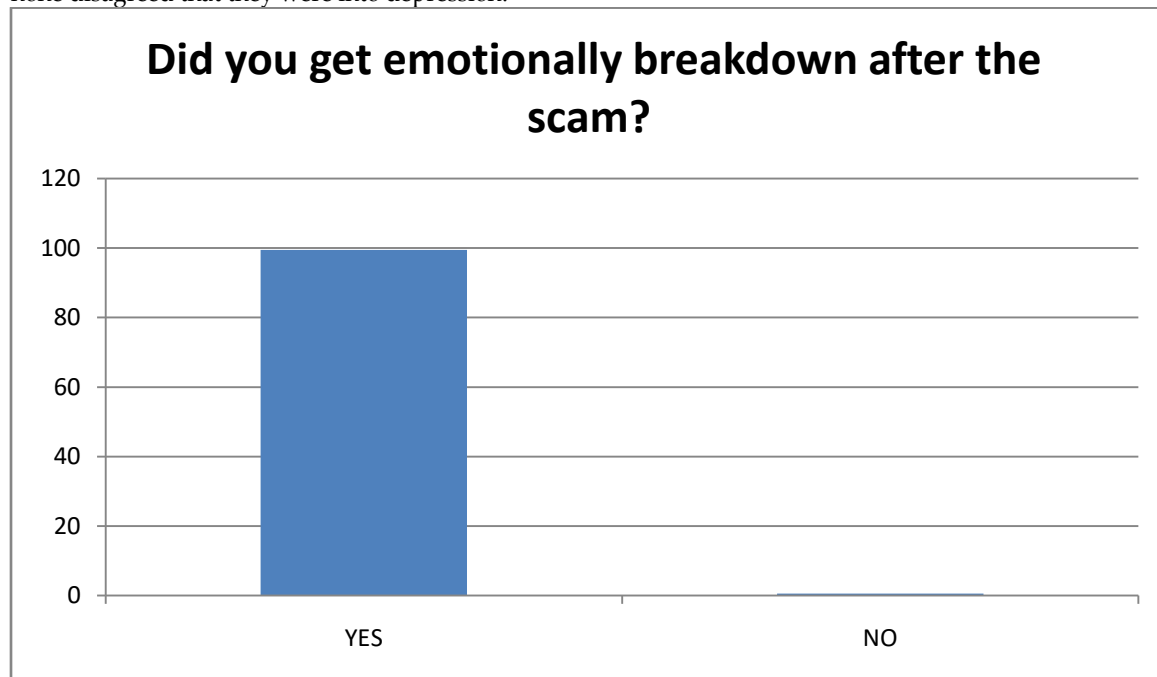


Fig 4: Shows the depression among the victims

Figure 4's graphs demonstrate that out of 179 respondents 178 respondents which are 99.45 percent of the total respondents have gone through an emotional breakdown, and only 0.55 percent has not gone through the emotional breakdown after the scam.





Amit Kumar Singh and Rahul Amin

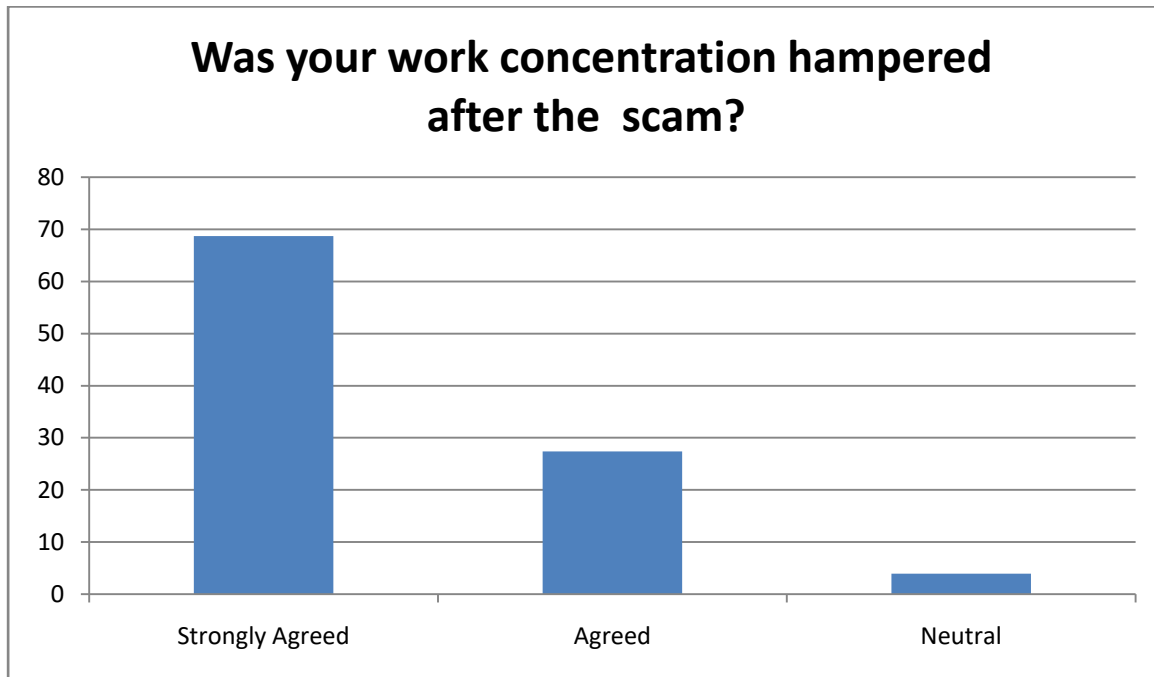


Fig 5: Shows the work Concentration

The graphs in figure 5 demonstrate that the work concentration of the victims was hampered. 68.71% of the victims strongly agreed that their work concentration was hampered because of the fraud they went through. 27.39% agreed that their work concentration was hampered only 3.91% have a neutral viewpoint.

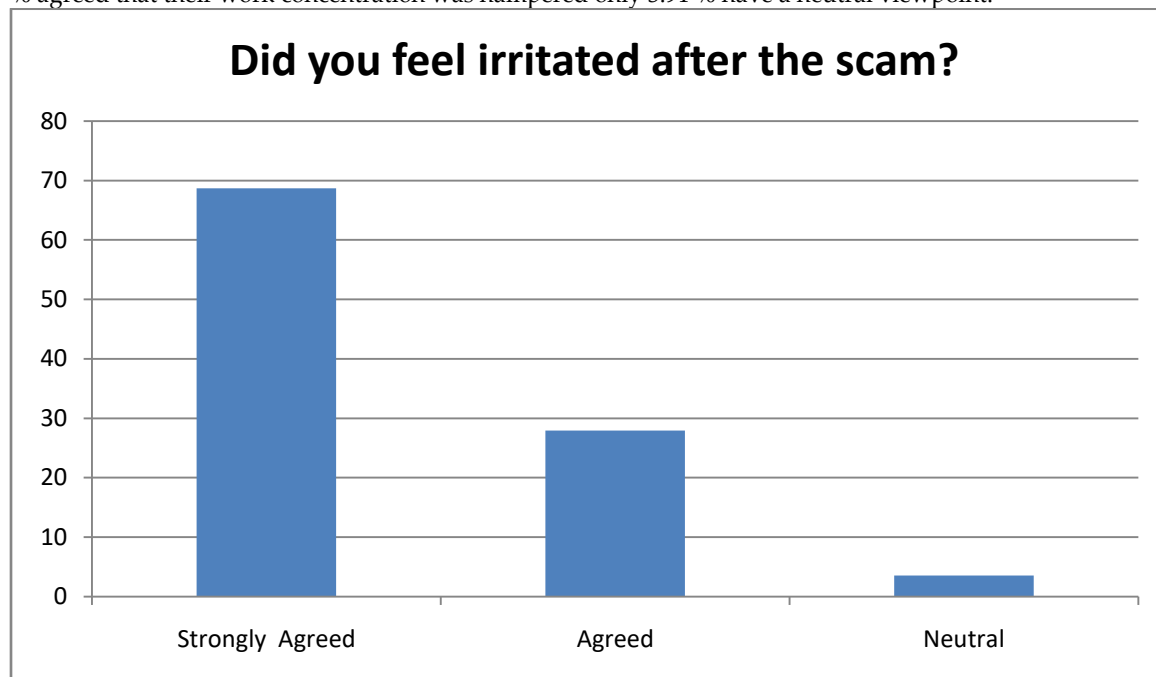


Fig 6: Shows the work Concentration

The graphs in figure 6 demonstrate the percentage of respondents who had irritated feelings after the scam. 68.71% of the total respondents strongly agreed with the statement that they felt very irritated right after the scam





**Amit Kumar Singh and Rahul Amin**

happened to them, whereas 27.93 % of respondents agreed that they have irritated feelings after they were defrauded, and only 3.55% of the respondents have a neutral opinion.

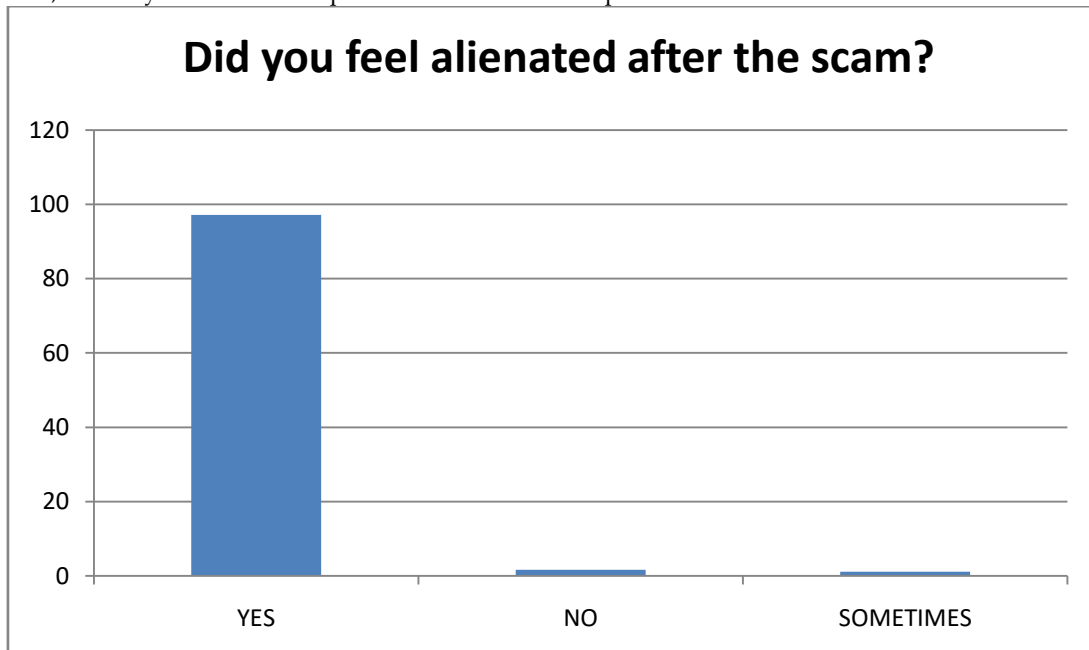


Fig 7: Shows the work Concentration

The graphs in figure 7 depict the percentage of the respondents who went alienated after they were defrauded. 97.20 % of respondents agreed that they went alienated. 1.11 % of respondents said they felt alienated sometimes, whereas 1.67% of the respondents never felt so.

**METHOD-II INTERVIEWS**

The researcher has prepared interview schedule. The interview schedule is based on the general questions related to the research topic. The researcher has included both close-ended and open-ended questions in the interview schedule, the use of online dating apps is considered sensitive, and the opinions expressed through survey methods may not be totally reliable, an interview of total 11 psychiatrists and psychologists was conducted to authenticate the results.

**FINDINGS OF THE INTERVIEWS**

The in-depth interviews brought out rich information and knowledge about the mental health of the victims residing in Jamshedpur, the results shows that the victims are male in most of the cases and they belong to a vulnerable age group of 20-25 years where they can be an easy prey of the scammer. The male to female ratio of victims are 60:40 the females those who are the victims belonged to the age group of 16-20 years. In case of female victims majority of these cases are blackmailing, as after spending some time together, the victim develops a very good equation with the scammer and the victim starts sharing their private photographs, which is later used as a blackmailing tool for the scammers. As a result the mental health statuses of the victims are they get into depression, they get anxiety disorder, Impulsive behaviour sometimes the victims get suicidal tendency, they get disturbed sleep cycle, and some follow the escapism. And these kinds of victims keep themselves isolated and every now and then they become alcoholic.





**Amit Kumar Singh and Rahul Amin**

## CONCLUSION

The research mentioned above offers fresh perspectives on the traits and experiences of those impacted by the online dating romance fraud. As per the findings, the victims of romance scams go through a lot of mental health issues. They go through many emotional damages and they also lose their mental composure. The victims very often get anxiety feelings, which also hamper their work. Other behavioral changes can be seen on them like they are irritated all the time. The materialistic loss is repairable but the kind of emotional breakdown they go through takes a lot of time to them to get back to normal. The victims get into depression sometimes they develop suicidal tendencies, sometimes they follow the escapism route to dodge the problem by alienating themselves from the surroundings but that also doesn't help the victim. Some people's experiences also caused them to lose faith in others. The mental stability of the victims is the major missing.

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# Quasi-Ideals and Quasi-Prime Ideals of Ternary Right Almost Semigroups

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## ABSTRACT

The notion of quasi-ideals and quasi-prime ideals of ternary right almost semigroups are introduced which is a generalization of semigroups. The characterizations of quasi-ideals and quasi-prime ideals of ternary right almost semigroups are discussed. The concept of quasi-ideal and quasi-prime ideal of ternary right almost semigroup with right identity is also discussed.

**Keywords:** Quasi ideal of ternary RA-semigroup, Quasi-ideal of ternary RA-subsemigroup, Quasi-ideal of ternary RA-semigroup with right identity, Quasi-prime ideal of ternary RA-semigroup, Quasi-prime ideal of ternary RA-subsemigroup, Quasi-prime ideal of ternary RA-semigroup with right identity.

**AMS Subject Classification code:** 17A40, 20N10

## INTRODUCTION

Algebraic structures are important in mathematics and have a wide range of applications in many fields such as physics, computer science, engineering, information science etc. Clifford and Preston [1] developed the algebraic

69998







**Ramesh and Mahendran**

theory of semigroups in 1961, while Kasner[7] investigated analogous structures earlier and proposed the concept of n-ary algebras. In 1980, Kim Ki Hang and Roush Fred [8] looked on ternary semigroup associative on each pair of factors in ternary semigroup. Universal algebras with one associative ternary operation are known as ternary semi groups. Dixit and Dewan [2,3] are credited with introducing the concept of quasi, bi-ideal and minimal quasi-ideal in ternary semigroup that cannot be reduced to a semigroup.

We examine the concept of Quasi-ideal and Quasi-prime ideal of ternary right almost semigroup, construct many examples and discuss some key topics in this paper. Some concepts and ideas to the ternary right almost semigroup's Quasi-ideal and Quasi-prime ideals are also discussed. We also look at Quasi-ideals and Quasi-prime ideals of ternary right almost semigroups and their characteristics.

**PRELIMINARIES**

**Definition 2.1.** A non-empty subset Q of a ternary RA-semigroup is called a quasi-ideal of S if

1.  $S(SQ) \cap S(QS) \cap Q(SS) \subseteq Q$ .
2.  $S(SQ) \cap (SS)(Q(S)) \cap Q(SS) \subseteq Q$ .

**Remark.** Let S be a ternary RA-semigroup.

1. Each Quasi-ideal Q of S is a ternary RA-subsemigroup, that is,  
 $Q(QQ) \subseteq (S(SQ) \cap S(QS) \cap Q(SS)) \subseteq Q$ .
2. Every right ideal of S is a quasi-ideal of S.

**Theorem 2.2.** Let S be a ternary RA-semigroup. If  $Q_i$  is a quasi-ideal of S, then  $\bigcap_{i \in I} Q_i$  is a quasi-ideal of S.

**Proof.** Suppose that  $Q_i$  is a quasi-ideal of S. Then  $S(SQ_i) \cap S(Q_iS) \cap Q_i(SS) \subseteq Q_i$  and  $S(SQ_i) \cap (SS)(Q_iS) \cap Q_i(SS) \subseteq Q_i$ . Then by the definition of quasi-ideal, we have

$$S(SQ_i) \cap S(Q_iS) \cap Q_i(SS) \subseteq Q_i$$

$$\begin{aligned} & S\left(S\left(\bigcap_{i \in I} Q_i\right)\right) \cap S\left(\left(\bigcap_{i \in I} Q_i\right)S\right) \cap \left(\bigcap_{i \in I} Q_i\right)(SS) \\ &= \bigcap_{i \in I} S(SQ_i) \cap \bigcap_{i \in I} S(Q_iS) \cap \bigcap_{i \in I} (Q_i(SS)) \\ &= \bigcap_{i \in I} S(SQ_i) \cap \bigcap_{i \in I} S(Q_iS) \cap \bigcap_{i \in I} (Q_i(SS)) \\ &\subseteq S(SQ_i) \cap S(Q_iS) \cap Q_i(SS) \\ &\subseteq (Q_i) \\ &S(SQ_i) \cap (SS)(Q_iS) \cap Q_i(SS) \subseteq Q_i. \end{aligned}$$

and

$$\begin{aligned} & S(SQ_i) \cap (SS)(Q_iS) \cap Q_i(SS) \subseteq Q_i \\ &= \bigcap_{i \in I} S(SQ_i) \cap \bigcap_{i \in I} (SS)(Q_iS) \cap \bigcap_{i \in I} (Q_i(SS)) \\ &\subseteq S(SQ_i) \cap (SS)(Q_iS) \cap Q_i(SS) \\ &\subseteq (Q_i) \end{aligned}$$

Therefore  $S(S(\bigcap_{i \in I} Q_i)) \cap S((\bigcap_{i \in I} Q_i)S) \cap (\bigcap_{i \in I} Q_i)(SS) \subseteq \bigcap_{i \in I} Q_i$  and

$$\left(\bigcap_{i \in I} S(SQ_i)\right) \cap \left(\bigcap_{i \in I} (SS)(Q_iS)\right) \cap \left(\bigcap_{i \in I} (Q_i(SS))\right) \subseteq \bigcap_{i \in I} Q_i$$

Hence  $\bigcap_{i \in I} Q_i$  is a quasi-ideal of S.

**Theorem 2.3.** Let S be a ternary RA-semigroup with right identity. Then  $aS^2 \cap S^2a$  is a quasi-ideal of S, for every  $a \in S$ .

**Proof.** Let S be a ternary RA-semigroup with right identity. Then by the definition of quasi-ideal, we have





**Ramesh and Mahendran**

$$\begin{aligned}
 S(S(a(SS) \cap (SS)a)) &= ((SS)a) \cap (a(SS)(SS)) \\
 &= ((SS)a) \cap (aS^2(SS)) \\
 &= ((SS)a) \cap (S(SaS^2)) \\
 &= ((SS)a) \cap ((SS)(aS^2)) \\
 &= (aS^2) \cap ((SS)((SS)a) \\
 &= (aS^2) \cap ((SS)(a(SS)) \\
 &= (aS^2) \cap ((SS)a(SS)) \\
 &= (aS^2) \cap (SS)a.
 \end{aligned}$$

Therefore  $S(S(aS^2 \cap S^2a)) \cap S(((aS^2) \cap (S^2a))S) \cap ((aS^2 \cap S^2a)S)S \subseteq aS^2 \cap S^2a$  and  
 $S(S(aS^2 \cap S^2a)) \cap S^2((aS^2 \cap S^2a)S^2) \cap ((aS^2 \cap S^2a)S)S \subseteq aS^2 \cap S^2a$   
Hence  $aS^2 \cap S^2a$  is a quasi-ideal of S.

**Theorem 2.4.** Let S be a ternary RA-semigroup with right identity. Then  $A \cup AS^2$  is a quasi-ideal of S, where  $\phi \neq A \subseteq S$ .

**Proof.** Let S be a ternary RA-semigroup with right identity. Then by the definition of quasi-ideal, we have

$$\begin{aligned}
 S(S(a(SS) \cap (SS)a)) &= ((SS)a) \cap (a(SS)(SS)) \\
 &= ((SS)a) \cap (aS^2(SS)) \\
 &= ((SS)a) \cap (S(SaS^2)) \\
 &= ((SS)a) \cap ((SS)(aS^2)) \\
 &= (aS^2) \cap ((SS)((SS)a) \\
 &= (aS^2) \cap ((SS)(a(SS)) \\
 &= (aS^2) \cap ((SS)a(SS)) \\
 &= (aS^2) \cap (SS)a.
 \end{aligned}$$

Therefore  $S(S(aS^2 \cap S^2a)) \cap S(((aS^2) \cap (S^2a))S) \cap ((aS^2 \cap S^2a)S)S \subseteq aS^2 \cap S^2a$  and  
 $S(S(aS^2 \cap S^2a)) \cap S^2((aS^2 \cap S^2a)S^2) \cap ((aS^2 \cap S^2a)S)S \subseteq aS^2 \cap S^2a$ .  
Hence  $aS^2 \cap S^2a$  is a quasi-ideal of S and  $A \cup AS^2$  is also a quasi-ideal of S.

**QUASI-PRIME IDEAL**

**Definition 3.1.** Let S be a ternary RA-semigroup. A right ideal P is called quasi-prime if  $A(BC) \subseteq P$  implies that  $A \subseteq P$  (or)  $B \subseteq P$  (or)  $C \subseteq P$  for all right ideals  $A, B, C \in S$ .

**Example 3.2.** Let  $S = \{0, -a, -b, -c\}$  be a ternary RA-semigroup with right identity  $a$ . Then  $\{0, -b\}$  is a quasi-prime ideal of S.

**Theorem 3.3.** Let S be a ternary RA-semigroup with right identity. Then a right ideal P of S is quasi-prime if and only if  $a_1(a_2a_3) \in P$  implies that  $a_1 \in P$  (or)  $a_2 \in P$  (or)  $a_3 \in P$ , and  $a_1, a_2, a_3 \in S$ .

**Proof.** Suppose that S is a ternary RA-semigroup with right identity. Let P be a right ideal of S. Then by the definition of right ideal, we have

$$\begin{aligned}
 (a_1(SS))((a_2(SS))(a_3(SS))) &= (a_1(SS))(a_2(SS)(a_3(SS))) \\
 &= (a_1(SS))(S(a_2S)(a_3(SS))) \\
 &= (a_1(SS))((SS)a_2(a_3(SS))) \\
 &= (a_1(SS))((SS)a_2a_3) \\
 &= (a_1(SS))(a_2a_3(SS)) \\
 &\subseteq a_1(a_2a_3)(SS) \\
 (a_1(SS))((a_2(SS))(a_3(SS))) &\subseteq P
 \end{aligned}$$

Thus  $a_1(SS)$ ,  $a_2(SS)$ ,  $a_3(SS)$  are right ideals S so that  
 $a_1(ee) \in a_1(SS) \subseteq P$  or  $a_2(ee) \in a_2(SS) \subseteq P$  or  $a_3(ee) \in a_3(SS) \subseteq P$ . Conversely, suppose that if  $a_1(a_2a_3) \in P$ , then  $a_1 \in P$  (or)  $a_2 \in P$  (or)  $a_3 \in P$ , and  $a_1, a_2, a_3 \in S$ . Suppose that  $A(BC) \subseteq P$  and A, B and C are right ideals of S such that  $A \not\subseteq P$  and  $B \not\subseteq P$ . Then there exists  $a_1 \in A, a_2 \in B$  such that  $a_1, a_2 \in P$ . Now consider  $a_1(a_2a_3) \in A(BC) \subseteq P$ , for all  $a_3 \in C$ . So by hypothesis,  $a_3 \in P$  for all  $a_3 \in C$  implies that  $C \subseteq P$ . Hence P is a quasi-prime ideal in S.





**Ramesh and Mahendran**

**Example 3.4.** In the ternary RA-semigroup  $Z$  of all negative integers, the ideal  $P = \{5x : x \in Z\}$  is a quasi-prime ideal of  $Z$ . But the ideal  $Q = \{385x : x \in Z\}$  is not a quasi-prime ideal of  $Z$ , since  $(-5)(-7)(-11) = -385 \in Q$ , but  $-5 \notin Q, -7 \notin Q$ , and  $-11 \notin Q$ .

**Theorem 3.5.** Let  $S$  be a ternary RA-semigroup with right identity. Then a right ideal  $P$  of  $S$  is quasi-prime if and only if  $a_1 a_2, a_3 \notin P$ , implies that  $a_1(a_2 a_3) \notin P$  for every  $a_1, a_2, a_3 \in S$ .

**Proof.** Suppose that  $S$  is a ternary RA-semigroup with right identity. Let  $P$  be a right ideal of  $S$ . Let  $a_1 a_2, a_3 \notin P \rightarrow a_1(a_2 a_3) \notin P$  and  $a_1, a_2, a_3 \in S$ . Then by the definition of right ideal, we have

$$\begin{aligned} ((a_1(SS))(a_2(SS)))(a_3(SS)) &= (SS)(a_3((a_1(SS))(a_2(SS)))) \\ &= (SS)[(a_2(SS))(a_1(SS)a_3)] \\ &= (SS)[(a_2(SS))(a_1 a_3)] \\ &= (a_1 a_3)[(a_2(SS))(SS)] \\ &\in (a_1 a_3)(a_2(SS)) \\ &\notin a_1(a_2 a_3)(SS) \end{aligned}$$

$$\left( (a_1(SS))(a_2(SS)) \right) (a_3(SS)) \notin P$$

Thus  $a_1(SS), a_2(SS), a_3(SS)$  are right ideals  $S$  so that,

$$a_1(ee) \in a_1(SS) \subseteq P \text{ or } a_2(ee) \in a_2(SS) \subseteq P \text{ or } a_3(ee) \in a_3(SS) \subseteq P.$$

Conversely, suppose that if  $a_1(a_2 a_3) \in P$ , then  $a_1 \in P$  (or)  $a_2 \in P$  (or)  $a_3 \in P$ , and  $a_1, a_2, a_3 \in S$ . Suppose that  $A(BC) \subseteq P$  and  $A, B$  and  $C$  are right ideals of  $S$  such that,  $A \not\subseteq P$  and  $B \not\subseteq P$ . Then there exists  $a_1 \in A, a_2 \in B$  such that  $a_1, a_2 \in P$ . That is  $a_1(a_2 a_3) \notin A(BC) \not\subseteq P$ . Hence  $P$  is a quasi-prime ideal in  $S$ .

**Theorem 3.6.** Let  $S$  be a ternary RA-semigroup with right identity. If  $A$  is a right ideal of  $S$  and  $P$  is a quasi-prime ideal of  $S$ , then  $A \cap P$  is a quasi-prime ideal of  $A$ .

**Proof.** Suppose that  $S$  is a ternary RA-semigroup with right identity. Clearly  $A \cap P$  is a right ideal of  $A$ . Let  $a_1(a_2 a_3) \in A \cap P$ . Then  $a_1(a_2 a_3) \in P$ , since  $A \cap P \subseteq P$ . Since  $S$  is a quasi-prime ideal of  $S$ , we have  $a_1 \in P$  (or)  $a_2 \in P$  (or)  $a_3 \in P$ . Therefore  $a_1 \in A \cap P$  or  $a_2 \in A \cap P$  or  $a_3 \in A \cap P$ . By the theorem [3.3], we get  $A \cap P$  is a quasi-prime ideal in  $S$ .

**Theorem 3.7.** Let  $S$  be a ternary RA-semigroup with right identity. If  $P$  is a quasi-prime ideal of  $S$ , then  $(P : a_1 : a_2)$  is a quasi-prime ideal of  $S$  and  $a_1, a_2 \in S$ .

**Proof.** Suppose that  $P$  is a quasi-prime ideal of  $S$ . We have  $(P : a_1 : a_2)$  is a right ideal in  $S$ . Let  $x(yz) \in (P : a_1 : a_2)$ . Then

$$\begin{aligned} (yz)(x(a_1 a_2)) &= (a_1 a_2)(x(yz)) \\ &= (x(yz))(a_1 a_2) \in P \end{aligned}$$

$$x(a_1 a_2) \in P(a_1 a_2) \subseteq P \text{ (or) } y(a_1 a_2) \in P(a_1 a_2) \subseteq P \text{ (or) } z(a_1 a_2) \in P(a_1 a_2) \subseteq P.$$

Therefore  $x \in (P : a_1 : a_2)$  (or)  $y \in (P : a_1 : a_2)$  (or)  $z \in (P : a_1 : a_2)$ .

Hence  $(P : a_1 : a_2)$  is a quasi-prime ideal of  $S$ .

**Theorem 3.8.** Let  $S$  be a ternary RA-semigroup with right identity. If  $P$  is a quasi-prime ideal of  $S$ , then  $(P : A : B)$  is a quasi-prime ideal of  $S$  and  $A, B \in S$ .

**Proof.** It is straight forward by the theorem 3.7.

**Theorem 3.9.** Let  $S$  be a ternary RA-semigroup with right identity. A right ideal  $P$  of  $S$  is a quasi-prime ideal if and only if  $S - P$  is either ternary RA-sub semigroup of  $S$  or empty.

**Proof.** Suppose that  $P$  is a quasi-prime ideal of  $S$  and  $S - P \neq \emptyset$ . Let  $a_1, a_2, a_3 \in S - P$ . Then  $a_1, a_2, a_3 \notin P$ . We get  $a_1(a_2 a_3) \notin P$  so  $a_1(a_2 a_3) \in S - P$ . Hence  $S - P$  is a ternary RA-subsemigroup of  $S$ . Conversely suppose that  $S - P$  is either ternary RA-subsemigroup of  $S$  or empty. If  $S - P$  is empty, then  $S = P$  and hence  $P$  is a quasi-prime ideal of  $S$ . Suppose that  $S - P$  is ternary RA-subsemigroup of  $S$ . Let  $a_1(a_2 a_3) \in P$ . Then  $a_1(a_2 a_3) \notin S - P$ . Since  $S - P$  is a ternary RA-subsemigroup, we get  $a_1 \notin S - P$  (or)  $a_2 \notin S - P$  (or)  $a_3 \notin S - P$ . Therefore  $a_1 \in P$  (or)  $a_2 \in P$  (or)  $a_3 \in P$ . Then we have  $P$  of  $S$  is a quasi-prime ideal of  $S$ .



**Ramesh and Mahendran**

## CONCLUSION

In this paper we discussed the characterizations of quasi-ideals and quasi-prime ideals of ternary right almost semigroups. The concept of quasi-ideals and quasi-prime ideals of ternary right almost semigroup with right identity are also discussed.

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## Artificial Intelligence and Literature: The Muse in the Machine

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### ABSTRACT

Artificial Intelligence or AI is the intelligence displayed by machines. Previously it was defined as Intelligence that mimics the human cognitive behaviour and skill set. But now AI is looked at and dealt with more rationality. AI has extended its wings to various fields like reasoning, learning, planning, execution, natural language processing etc. Software implications of artificial intelligence (AI) have been extended to a wide range of fields, ranging from interpreting human speech. Recent examples include the Siri and Alexa services offered by Apple and Amazon, the Tesla self-driving cars, numerous game apps, web searches, etc. AI does, however, have its limitations because it is constantly constrained by the information that is currently available and is never able to analyze data creatively, as a human mind can. This paper aims to study the limitations of AI when it comes to creative writing and how it can never replace screenwriters or create film plots even with the plethora of information that it possesses.

**Keywords:** Artificial Intelligence, creative limitations, literature, script creation

### INTRODUCTION

AI is computing that strives to perform human tasks, but better. It includes perceiving, thinking (including comprehending and producing words in the manner of Siri and Alexa), learning, predicting, decision-making, and following commands (Drones and autonomous vehicles like Tesla). Modern AI requires efficient learning algorithms and an abundance of extremely potent data for pattern recognition training to accomplish all this effectively. Artificial neural networks, which are biologically inspired programs based on the neural networks of the brain, are currently the most well-liked and effective algorithms [1,2]. The information is particular to the apps. For instance, all of our online choices, such as what we read, watch, click on, and buy, give useful data to AI algorithms that are





**Balagopal and Richa Arora**

working to better serve us, especially when it comes to giving us customized adverts to enhance the likelihood that we will make an online purchase.

**The domain of AI**

AI is everywhere. The age of artificial intelligence is here. It is taking over a range of professions, tools, media, and technology and promises to alter every aspect of life, from business and industry to healthcare and education. It is pervasive but mostly unnoticeable.[3,4]. AI has been influencing human beings heavily, even for day-to-day errands like telling us how to reach a destination with the help of on board navigation and pitching in suggestions when buying something online based on previous purchases. Human beings have gotten highly accustomed to AI that even if a person knows how to drive to a location, navigation assistance is still used as a form of convenience.

**Advantages of AI**

As modern AI is often more efficient and effective than people, reliance on it is unavoidable. In addition to defeating humans at chess and Jeopardy, it can assess radiological pictures more accurately than radiologists and prevent accidents more effectively than truck drivers, sparing lives in both situations. The most important objective of pedagogy has always been to give each student education that is clever, caring, and specific to their needs. AI promises to make this happen. AI might provide tailored activities and learning materials for each student, as well as the pace and education style that works best for them.[5]. The program's intelligence increases as a result of data-driven learning and machine learning, which results in stronger predictions and judgments from AI. If there are more high-quality data available for training, the outcome will be better. This constant cycle of self-improvement strengthens the program's powers. It is similar to a number of basic positive feedback mechanisms.

**Constraints of AI**

If there is a lack of data or the data is unclear, the AI algorithm may perform increasingly worse, becoming less and less intelligent. For instance, if you randomly click on internet advertisements, you are giving AI data that is worthless and perplexing. In this instance, AI must recognize this right away. Otherwise, it will be using corrupt data to learn, which could result in inaccurate forecasts and poor choices. A new age has actually begun as a result of artificial intelligence technology's development and widespread use. Even though artificial intelligence has achieved tremendous success and is all around us, certain people frequently criticize it and voice grave worries. In truth, artificial intelligence was something that the late Stephen Hawking was adamantly opposed to. It should be noted that Hawking is not against artificial intelligence but is concerned that super AI may cause a number of unanticipated difficulties for people in the future. According to Hawking, "The long-term impact of artificial intelligence depends on whether it can be managed, and the short-term impact depends on who controls it" [6].

**Future of AI**

Artificial intelligence is developing at an accelerating rate. Artificial intelligence (AI) developments will have profound social repercussions. Over the next ten years, self-driving technology may displace millions of driving jobs. In addition to potential job losses, the transition will present new difficulties, including the need to repair infrastructure, safeguard automotive safety, and modify laws and regulations[7]. Not just Hawking, but many others are questioning whether there are moral restrictions on the development of artificial intelligence. AI has recently continued to have an impact on film and television, as well as in academic disciplines like medicine and scriptwriting. Many people are interested in the potential effects of AI on literature and whether it might eventually take the position of human screenwriters. If artificial intelligence does reach this level, human concerns about it will come true, and people may even be forced to submit to it or face dire consequences[8].

**THE CREATIVE ASPECT OF LITERATURE WHICH AI LACKS**

AI is limited to information processing based on algorithms and programs as it cannot understand the underlying meaning of texts or the emotion that it hopes to induce in a reader. The randomness that natural intelligence possesses cannot be effectively replicated by AI as it strictly abides by fixed rules and commands. This makes natural intelligence superior when it comes to uniqueness. Grace[9], in her quantitative paper with the help of AI experts, predicts the point where AI will become advanced enough to replace all human tasks based on a phenomenon called HLMI (High-level machine intelligence) and concludes that it's at least a century away due to intelligence-explosion which is a point where AI is able to research and develop on its own which creates exponential growth in its



**Balagopal and Richa Arora**

capabilities in a short period of time. It's also noted that AI attaining such feats is improbable as it is unable to create unique data on its own even with its ability of deep learning. Scriptwriting or authoring is a highly creative process. There are multiple aspects to it which impact the outcome of an idea that later turns into a script. It's part of a complex thought process which involves passion for a certain area, innovative thinking from a unique perspective and human rational thinking[8].

**Passion for Creation and Creation from Life**

Let's revisit the definition of literary production as script writing comes under it. Through artistic processing, a writer expresses their aesthetic experience of life in their literary works, such as poetry, novels, essays, plays, and scripts, allowing readers to appreciate the creative processes which is obtained through real life experiences. The act of thinking and feeling is crucial to creation since it is a form of spiritual production. First and foremost, genuine literary production is predicated on the writer's intense passion for books. A writer may only maintain a deep interest in literature if he is willing to endure persecution, imprisonment, exile, and beheading for it. He can devote his entire body and mind to literary creation. The art of writing a script or coming up with an idea for a story can happen at any random place and time in a human mind irrespective of what time and place the person is exposed to. The human mind doesn't function under just optimal conditions like AI can. It totally depends on what that individual mind is going through at that point in time. This is more apparent when it comes to analyzing and appreciating art. A reader who is not interested in literary works will not become enthusiastic about reading and will be unmoved by any great literary works. Because a good writer must also be a good reader, as we all know, a writer is first and foremost an avid reader. His perspective will only expand with substantial reading, which will also ignite his prolific zeal, awaken his literary conscience, and inspire his literary imagination.

Passion plays an integral part in the creation of unique ideas that give birth to amazing scripts like *Interstellar* and *Shaw Shank Redemption*. Three points of creation, seven points of life, and "from life, higher than life" are concepts that are frequently reflected in literary creativity<sup>10</sup>. The same goes for a screenwriter. To write the truth about *The Times*, the truth about life, and the truth about humanity, a screenwriter must dedicate himself to the in-depth observation, experience, and reflection of society. He has to "fight" with reality and light the literary and artistic sparks with the fire of his own existence. Only after taking this step can a screenwriter genuinely comprehend the time, comprehend human nature, and convey their own innermost, most genuine ideas and thoughts about society. The limited computer science vocabulary, which includes terms like storage, extraction, input, and output, falls short of adequately describing this type of experience. Artificial intelligence creation cannot be compared to human culture creation due to the lack of experience.

**Innovation and Human Rational Thinking**

Writing, painting, and scriptwriting are all founded on the authors' personal and life experiences, and as a result, truly effect literary and artistic works have distinctive life traits. When it comes to AI, before writing, it must first receive knowledge from dozens of sci-fi film scripts. The script is then divided into foundation levels. The key benefit of this is that it may foretell which letters in a science-fiction script will be used in conjunction more frequently. This method of analysis takes away the soul of the script as the impact of the storyline lasts only when all the elements come together in that specific order, not individually[11]. As a result, artificial intelligence-generated works are just the result of a computer gathering and combining information from a database of previously published works. The diversity of the works created by a single author should also be reflected in literary and creative works, rather than just the personalities of different authors. Artificial intelligence is helpless in this regard because all it can do is mimic the writing style of humans; however, without their individual personalities, fixed styles cannot be produced[12]. Furthermore, the ability to reason and think critically is one of the fundamental qualities of artificial intelligence. A good screenplay should be able to embody this ability. There is a fundamental difference between a human and an artificial intelligence that can comprehend the definition of a word or a plotline to convey deep meaning, thus creating a unique story. Symbols can be operated on computers primarily by following a set of algorithmic rules and performing certain tasks. AI is unable to effectively decipher the symbols the way natural intelligence or human intelligence would, according to the trial conducted by the scriptwriting AI, Benjamin, a recursive neural network, which was unable to create a convincing plot after analyzing popular film



**Balagopal and Richa Arora**

scripts[8]. AI is unable to find meaning in most of the poetic literary works that a well-read human mind can easily comprehend and dissect.

**FUTURE OF AI IN SCRIPT CREATION**

AI does have its advantages over the human mind when it comes to logic and strategy-based areas which does show how rapidly AI is developing throughout the years. In fact, artificial intelligence is progressing quickly right now, as evidenced by Alpha Go's victory over the world Go champion, which is a milestone in the field's development. Alpha Go can, however, study a significant number of chess charts taught by humans and continue to practice using its powerful computer capabilities in the literary fields of go and scriptwriting. Precipitation into a vast rule library, forecast the potential chess pieces of the adversary, algorithm prediction in the system, followed by the shifting environment, alter the distribution list of the likelihood of the collapse of the chess pieces in the network to identify a move with a higher possibility. This requires thought and computation in and of itself. Scriptwriters as well as other literary works are very different. They provide spiritual support and comfort for people, and occasionally they even serve as a type of inheritance. They cannot be chosen using probability theory or measurable assessment, and their evaluation criteria cannot be proven to be accurate or wrong<sup>12</sup>. Even if some may argue that AI cannot be replaced at the present time, let's revisit the early stages of its creation to see if this is true.

The first stage of artificial intelligence is weak AI, which excels in a single area of the field. For example, Alpha Go is the current world champion at Go, but it can only play chess; if you let it drive your car, it will undoubtedly not function. At this stage of society, AI is not very useful in areas where humans excel. The next level of AI, often known as strong artificial intelligence, that can match human intelligence in all respects, is the second level. It can perform all mental tasks that people are capable of. Strong artificial intelligence is far more challenging to develop than weak artificial intelligence. Super-artificial intelligence, which is the third level, refers to being far smarter than the brightest human minds in practically every sector, including technical innovation, general knowledge, and social abilities. The third stage is the most conducive to literary production in the description from the standpoint of these three stages. Although it may only be at a theoretical level, it is unclear whether this stage will ever be achieved. If artificial intelligence were to advance to the third stage, it is unlikely that it would be able to develop emotional intelligence. Instead, it would likely be capable of large-scale computing under extremely quick learning conditions. Lack of growth, experience, communication, interest, and zeal are all essential components of literary creation[13].

**CONCLUSION**

Artificial intelligence cannot take the place of human authors in fields like literature since human nature continues to advance. It should be recognized that the use of artificial intelligence in the production of literature and art has important implications for advancing the growth of literature and art, whether in terms of modes of expression, patterns of creativity, or the extension of imaginative space. Our production efficiency in some text sectors has undoubtedly increased because of the development of artificial intelligence in this regard. The listed firm profits are swiftly created by means of artificial intelligence, like some organized powerful press releases, and these earnings can significantly increase operating efficiency and current capacity. The artificial intelligence-powered editor robot can classify text, extract keywords, and classify participles. It can replace a lot of manual labour that was previously required and produces work of a higher caliber than people. All of these can increase the effectiveness of text processing after production<sup>14</sup>. It is possible to assume that human literature and art will continue to exist if computers cannot bridge the cognitive gap between humans and their own spiritual creations. Shakespeare and Mark Twain were not realistic when they were created by artificial intelligence, but they are now playing increasingly significant roles in literature. Freeing humans from some menial, repetitive work, allows people to devote more time to more meaningful endeavours, such as the richer development of the soul. AI therefore cannot completely replace literature, but it may greatly aid human authors not just screenwriters, but all authors of literary works[8].



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## Wound Healing Potential of Siddha Herbo Mineral Formulation *Mathan Thailam* – A Review

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### ABSTRACT

*Mathan thailam* is a Siddha herbomineral formulation coded in the text Siddha Formulary of India Part – I and is been widely used in the clinical practice for the treatment of *Pun* (Ulcer), *Pilavai* (Abscess), *Kaathuu Pun* (Ear Infections), *Sizh vadithal* (Pus discharge), eczema, weeping eczema, itches, bed sores, anal fistula, ear infections, carbuncle ulcer of diabetes, peri anal abscess, non-healing ulcers, folliculitis, alopecia and burn wound etc., Chronic wounds are ulcers that do not heal in timely and organised manner within three months. The management of these chronic non healing ulcer is a huge challenge to the healthcare system and the patients as it poses a huge financial burden and affects the quality of life of patients. These challenges in the management of chronic non healing ulcers can be met by *Mathan thailam* as its cost effective and has high therapeutic effectiveness. Hence this article scientifically analysed the wound healing capacity of its ingredients. The review showed that all the ingredients possess potent wound healing activity, antioxidant activity and antimicrobial activity. This review may act as evidences for further preclinical studies and clinical trials for its use in treating Chronic non healing wounds.

**Keywords:** Mathan Thailam, Siddha, Wound healing, Chronic wounds, antioxidant, antimicrobial.







Subhashri et al.,

## INTRODUCTION

Siddha system of medicine is one of the oldest codified healthcare systems in the southern parts of the Indian subcontinent with unique principles and philosophies which consider the human body as a conglomeration of 3 biological humor and 7 body constituents. Siddha system has classified the medicines into 32 types of *Ulmarundugal* (Internal medicines) and 32 Types of *Puramarundugal* (External medicines). *Thailam* (medicated oil) is one of the *Puramarundugal* (External medicines) which are prepared by boiling decoctions, juices or pastes of raw materials with oil. It is used both for internal and external purposes. In external usage, *thailam* can be used as *Poochu* (Anointing) or can be applied on a gauze or plaster which can be used to promote wound healing (*Seelai* - Medicated Gauze). There are enormous *Thailam* formulations indicated in the Siddha texts for the treatment of *Viranam* (Wounds or Ulcers) (1). One among them is the *Mathan Thailam*, an herbo mineral Siddha formulation coded in Siddha Formulary of India Part I, indicated for the treatment of *Pun* (Ulcer), *Pilavai* (Abscess), *Kaathuu Pun* (Ear Infections) and *Sizh vadithal* (Pus discharge) (2). But in clinical practice it is widely used for treating several conditions like eczema, weeping eczema, itches, wounds, chronic ulcers, bed sores, anal fistula, ear infections, carbuncle ulcer of diabetes, peri anal abscess, non-healing ulcers, folliculitis, alopecia and burn wound etc., (3) Wound healing process consists of four phases such as hemostasis, inflammation, proliferation, and remodeling phases. A wound is considered chronic if it has not healed in a timely and organised manner to create anatomical and functional integrity within three months or if the healing process has continued without producing a long-lasting anatomical and functional outcome. The Wound Healing Society divides chronic wounds into four groups based on the underlying aetiologies: pressure ulcers, diabetic ulcers, venous ulcers, and arterial insufficiency ulcers (4). Wound care is a multibillion-dollar global issue, it affects 5.7 million individuals (~2% of the population) in the USA, where it costs \$20 billion a year. According to a UK survey, affluent countries spend 3% of their entire healthcare budget on treating and caring for people with chronic wounds. These wounds take decades to heal, and others may take years to heal at all. Patients may suffer from excruciating pain, extreme emotional and physical discomfort, decreased mobility, and social isolation throughout this time (5). Wound care plays an important part in the management of Chronic wounds, Wound dressings helps to protect the wound from injury and also promotes wound healing. Ideal wound dressing material in the management of chronic ulcers should absorb exudate without leakage, maintain moist environment, provide thermal insulation, allow permeability to water, optimise pH, minimise wound infection, avoid trauma, provide pain relief and be comfortable (6).

These criteria can be fulfilled by wound dressing with Siddha topical medicine *Mathan Thailam* which possesses a good clinical efficacy, lesser adverse effects and is cost effective which can make it an affordable treatment modality for patients of all socioeconomic categories. Hence this article aims at analysing the action of each ingredient and its importance in treating chronic wounds.

## METHODOLOGY

The formulation and the organoleptic characters of the ingredients were collected from classical Siddha texts, the phytochemical constituents and pharmacological activities were searched from databases such as Google scholar, Pubmed, etc., with keywords such as name of the ingredients, along with words such as Phytoconstituents, wound healing activity, anti-oxidant activity, anti-microbial activity and anti-inflammatory and the results are listed below.

### COMPOSITION OF MATHAN THAILAM (2):

The composition of *Mathan Thailam* is listed in Table No: I.





Subhashri et al.,

**PREPARATION OF MATHAN THAILAM (2):**

Purified *Thurusu* (Copper sulfate) is dissolved in *Ummathai ellai saaru* (D. metel leaf juice). *Thengai Ennai* (Coconut oil) is then added, mixed and heated (preferably by fire wood) on mild flame in a properly seasoned clay vessel. Mixture in the vessel should be stirred intermittently till it attains required consistency (*Kadugu thiralum pakuvam*). Finally, the content is filtered through muslin cloth, cooled and stored in an air tight container.

**ORGANOLEPTIC CHARACTERS AND THERAPEUTIC USES OF THE INGREDIENTS OF MATHAN THAILAM:**

The organoleptic characters and the therapeutic uses of the ingredients are listed in Table No: II

**UMMATHAI (DATURA METEL)****Botanical Description**

It is an annual, erect, pubescent shrubs, clothes with glandular tomentum, up to 1 metre tall. Stem and plant parts tinged purple in colour. Leaves are variable, ovate, base unequal. Flowers are pinkish violet, solitary and axillary. Fruit is globose capsule, with short, stout, blunt spines. Probably native of America but long introduced and naturalised in Asia (8).

**Taxonomic description (8):**

Kingdom	:	Plantae
Phylum	:	Tracheophyta
Class	:	Magnoliopsida
Order	:	Solanales
Family	:	Solanaceae
Genus	:	<i>Datura</i>
Species	:	<i>Datura metel L.</i>

**Phytochemical Constituents:**

Different *D. metel* leaf extracts (methanol, chloroform, ethyl acetate, petroleum ether) were screened for their phytochemical composition, and the results revealed the presence of flavonoids, alkaloids, saponins, tannins, phenols, proteins, cardiac glycosides, terpenoids, and carbohydrates. The maximum amount of phytoconstituents were found in methanol extract, which also included the highest amounts of phenol, alkaloid, flavonoid, and tannin at 124.61 0.68 mg GAE/g, 88.77 1.01 mg AE/g, 42.24 0.18 mg QE/g, and 38.72 0.51 mg GAE/g, respectively (20). The total alkaloid content of the leaves was 0.426% which were mainly hyoscyamine, scopolamine, atropine and withanolides (8)

**Pharmacological Actions****Antimicrobial Propertie**

M Prasathkumar et al. demonstrated that the methanolic extract of *D. metel* leaf at various concentrations had potent antibacterial properties against *Bacillus subtilis*, Methicillin-resistant *Staphylococcus aureus* (MRSA), *Escherichia coli* and *Pseudomonas aeruginosa* with a zone of inhibition ranging from (12.66±0.13 to 11.62±0.65mm) at various concentrations. Furthermore, when compared to the control group, the two different doses of methanolic extract (50 and 100 g/mL) significantly decreased the biofilm development against all of the tested pathogens. The methanolic extract's maximum inhibitory effects were observed at 100 g/mL, which resulted in biofilm inhibition of 94.14 ± 0.27, 88.73 ± 1.51, and 92.38 ± 1.81% against *B. subtilis*, MRSA, and *E. coli* (9).

Okwu DE et al, demonstrated that a new antibacterial compound 51, 71 dimethyl 61-hydroxy 31-phenyl amine 1, isolated from *Datura metel* leaves possess anti-bacterial activity against *Proteus mirabilis*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *E. coli*, *Salmonella typhi*, and *Bacillus subtilis* with a zone of inhibition of ranging from 5.0±0.10 to 10.0±0.02 mm through in vitro method (10)





Subhashri et al.,

**Antioxidant Properties**

Rajesh Matcha et al., conducted DPPH radical scavenging, total antioxidant, and total phenolic content studies to determine the antioxidant activity of methanol and aqueous extract. When ascorbic acid was used as the reference, methanol and aqueous extract of *D. metel* leaf demonstrated antioxidant efficacy in DPPH radical scavenging activity. The aqueous extract of *D. metel*'s leaves showed inhibition in different concentrations from  $16.26 \pm 0.23$  to  $53.52 \pm 0.55$  and the IC<sub>50</sub> value was 74.0 ug/ml. The percentage of inhibition of methanolic extract in different concentrations ranged from  $22.16 \pm 0.43$  to  $62.67 \pm 0.75$  and the IC<sub>50</sub> value was 56.34 ug/ml. In contrast, the percentage of inhibition of ascorbic acid in different concentrations ranged from  $23.55 \pm 0.56$  to  $78.06 \pm 0.23$  with an IC<sub>50</sub> value of 36.28 ug/ml.

Then on studying the total phenols by Foiln-Ciocalteau's calorimetric method. The results showed that percentage of phenolic in methanolic extract was  $1.989 \pm 0.58$ , whereas the gallic acid equivalent of the methanolic extract of plant was  $19.893 \pm 0.52$ . The percentage of phenolic in aqueous extract was  $1.235 \pm 0.46$ , whereas the gallic acid equivalent of the aqueous extract of plant was  $12.352 \pm 0.73$ . In determining the total antioxidant activity through phosphorous molybdenum method. The total antioxidant capacity on expressing as equivalent of ascorbic acid per gram of plant sample was  $23.360 \pm 0.67$  for methanolic extract and  $13.334 \pm 0.64$  for aqueous extract <sup>(11)</sup>.

**Wound Healing activity:**

M Prasathkumar et al. used the fibroblast cells migration/proliferation scratch experiment in L929 mouse fibroblast for 24 hours to investigate the wound healing potential of the methanolic extract (5, 25, and 50 g/mL) of *D. metel* leaves. For the same time periods (8 & 24 hours), the wound closure was higher in the 50 g/mL group (79.31 1.55 & 100%) than in the control group (22.83 2.14-41.55 & 1.62%). The methanolic extract's cell density was found to be significantly higher than that of the untreated cells (10). Anitha V et al, evaluated the wound healing potential of the ethanolic extract of *Datura fastuosa* formulated as an ointment at two concentrations (5% and 10% w/w) using different models such as excision, incision and dead space. The result showed that the extract treated wound epithelised on 16<sup>th</sup> and 14<sup>th</sup> day when treated with 5 %w/w & 10%w/w ointment. There was a significant increase in the skin tensile strength of the treated group on the tenth postwounding day and produced a significant increase in the wet granuloma weight and dry granuloma weight in incision and dead space wound model. There was an increase in the biochemical parameters in the early stages of healing process (4<sup>th</sup>, 8<sup>th</sup>& 12<sup>th</sup> day) and almost equivalent to the control in the later stage (12<sup>th</sup> day). The result suggested that 10%w/w *Datura fastuosa* ointment exhibit significant wound healing activity as that of the standard <sup>(12)</sup>.

**THENGAI ENNAI (COCOS NUCIFERA)****Botanical Description**

The coconut palm tree has a single trunk about 20 to 30 metres tall and has smooth, grey bark that is surrounded by scars from leaf bases that have fallen. The leaves are 4-6 m long, pinnate leaves, slightly recurved and brilliant green in colour. Inflorescences are unbranched spadices. Male flowers are present near the apex and the female flowers are present basally. Flowers are polygamous monoecious flowers. The fruit is drupe and has three layers namely, exocarp, mesocarp, and endocarp (13).

**Taxonomic description (13):**

Kingdom: Plantae  
Phylum: Tracheophyta  
Class: Magnoliopsida  
Order: Arecales  
Family: Arecaceae  
Genus: *Cocos*  
Species: *Cocos nucifera* L.





Subhashri et al.,

**Phytochemical constituents**

Saturated fatty acids, make up about 90% of the oil's total fatty acid composition. Among which medium chain fatty acids make up about 64%. The most prevalent medium chain fatty acid in this oil is lauric acid (40–50%). Sterol, volatile chemicals and phospholipids and tocopherols are said to be present in this oil. Gallic acid, hydroxyphenolic acid, vanillic acid, syringic acid, p-coumaric acid, caffeic acid, ferulic acid, and cinnamic acid are the phenolics identified in this oil, and they are responsible for the variety of pharmacological actions of the oil. The principal triacylglycerols found are trilaurin (19%), diaurylcapryl glycerol (19%), diaurylmyristyl glycerol (10%), and lauryldicapryl glycerol (10%). This oil contains three major phospholipids: phosphatidylcholine (34.6%), phosphatidylethanolamine and phosphatidylinositol (19.0%). Coconut oil has the lowest concentration of tocopherols (0.32 mg/100g) compared to other plant oils (14).

**Pharmacological activities****Wound healing activity**

According to Srivastava et al.'s investigation into the partial thickness burn wound healing properties of *Cocos nucifera* oil in *Wistar albino* rats. The results showed a significant improvement in burn wound contraction in the group treated with the combination of *Cocos nucifera* and silver sulphadiazine and a significant decrease in the period of epithelialization in both the only and combined treatment groups (15). Young rats were used in an excisional wound model in Niven et al.'s investigation of virgin coconut oil's capacity to heal wounds. The findings indicated that the VCO-treated group recovered more quickly, as seen by a reduction in epithelisation time. The evaluation of skin parameters revealed an increase in the Pepsin-soluble collagen content, Glycylglycolase activities, and antioxidant enzyme activities in the VCO treated group, in addition, glutathione, malondialdehyde, and lipid peroxide levels were low in the treated wounds. In comparison to controls, histopathological examination of wounds revealed increased fibroblast proliferation and neovascularization in VCO-treated wounds (16).

**Anti-oxidant activity:**

The commercial coconut oil had the highest levels of total phenol ( $0.94 \pm 0.04$  mg gallic acid eq./g dry copra), antioxidant activity (DPPH activity, IC<sub>50</sub> value  $0.77 \pm 0.78$  mg/mL), and reducing power ( $40.49 \pm 1.84$  mg BHT eq./g dry copra) among all the extracts (aqueous & n-hexane) & oils (commercial oil & Soxhlet extracted oil), according to PK Ghosh et al (17). Idu M. et al. used the total antioxidant capacity assay and the FRAP assay to compare the antioxidant capacity of cold and hot-pressed coconut oil. The results showed no discernible difference between CP oil ( $128.44 \pm 6.10$  mg ascorbic acid eq. /g extract) and HP oil ( $152.54 \pm 6.00$  mg ascorbic acid eq. /g extract) in terms of antioxidant capacity. However, CP oil's antioxidant capacity was a little bit higher than HP oils. Compared to HP oil ( $594.00 \pm 17.67$  M Fe (II) /g extract), CP oil ( $692.50 \pm 30.50$  M Fe (II) /g extract) showed a much higher FRAP value (18).

**Antimicrobial activity**

Lauric acid, a fatty acid found in coconut oil, Abbas et al tested this acid for its in vitro antibacterial properties against a variety of clinical isolates, such as *Staphylococcus aureus*, *Streptococcus species*, *Lactobacillus species*, and *Escherichia coli*. With the highest zone of inhibition on *Staphylococcus aureus* (10.50 mm), *Streptococcus species* (10.00 mm), *Lactobacillus species* (10.00 mm), and the lowest inhibition on *Escherichia coli* (4.00 mm), at the Minimum Inhibitory Concentration (MIC), lauric acid demonstrated significantly appreciable antimicrobial effect. *Escherichia coli*, which even at the maximum dilution concentration displayed a rather low zone of inhibition (19). Shino B et al, compared the antifungal activity of coconut oil, probiotics, *Lactobacillus* and Chlorhexidine with that of ketoconazole on *Candida albicans* isolated from early childhood carriers, the mean zone of inhibition for chlorhexidine was 21.8 mm, whereas for coconut oil, probiotics, and *Lactobacillus* it was 16.8 mm, 13.5 mm, and 22.3 mm, respectively. Similar to ketoconazole, chlorhexidine and coconut oil have demonstrated strong antifungal action (20).

**THURUSU (COPPER SULPHATE)****Role of Copper in wound healing**

Angiogenesis, the physiological process by which new blood vessels develop from pre-existing vessels, is crucial during the proliferative stage of wound healing, Copper has been a well-known angiogenic factor for more than 20



**Subhashri et al.,**

years. Angiogenetic potential of the copper is mainly due to its interaction with VEGF and to a lesser extent with the angiogenin. Sen et al. demonstrated the copper's angiogenic potential by promoting the healing of cutaneous wounds. They demonstrated that copper sulphate speeded up the healing of excisional wounds in murine dermis on topical application at a concentration 25  $\mu\text{M}$ , once daily for five days raised VEGF expression, and enhanced the quality of newly formed tissue. Furthermore, histological examination of the wound edge revealed more hyperproliferative epidermis, increased connective tissue deposition, and higher cell densities in the granulation layer in the copper sulphate treated group.

The two main protease groups involved in the healing of wounds are matrix metalloproteinases (MMP-1, MMP-2, MMP-8, MMP-9) and serine proteases (human neutrophil elastase, HNE). These proteases control the activity of growth factors and inflammatory mediators, remove damaged proteins, promote cellular migration, and remodel the granulation tissue. Studies showed that low copper concentrations (0.3–3  $\mu\text{M}$ ) stimulate MMP activity, but high values (1–100  $\mu\text{M}$ ) stimulate MMP expression in fibroblasts. MMP2 and MMP3 can both be upregulated by copper but excess free metal can also stop MMP actions.

The complex of copper ions with glycyl-L-histidyl-L-lysine (GHK-Cu) increases the expression of proteins like collagen, elastin, metalloproteinases, vascular endothelial growth factor, fibroblast growth factor, and nerve growth factor, which thereby promotes the proliferation and remodelling phases of healing. A family of proteins called integrins are important in intercellular and cell-substrate adhesion, which is an essential process in tissue repair and wound healing. Copper has been shown to alter the expression of integrins engaged during the last phase of healing ( $\alpha 2$ ,  $\beta 1$  and  $\alpha 6$ ) in proliferating monolayer cultures of keratinocytes.

Lysyl oxidase, a copper-dependent enzyme, is required for remodelling of the extracellular matrix as well as during the proliferative stage of healing. The use of copper as an antibacterial agent has garnered renewed interest, and copper-based nanomaterials and nanoparticles have appeared with the potential to be used as wound dressings. J. Ramyadevi et al. created copper nanoparticles using a modified polyol method and investigated their antimicrobial effects on a variety of bacteria and fungi, including *Candida albicans*, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae*, *Micrococcus luteus*, and *Staphylococcus aureus*. The copper nanoparticles demonstrated greater bacterial than fungal inhibitory action, and they also demonstrated a greater zone of inhibition in *E. coli* (26 mm) than *C. albicans* (23 mm) (21,22).

## CONCLUSION

This review will give valuable information which will assist the health care professionals in getting more advanced knowledge about the scientific activities of ingredients of *Mathan Thailam*. Further clinical trials should be carried out to develop the scientific evidence for the uses of this thailam in treating Chronic non healing wounds.

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Table No I: Composition of Mathan Thailam:

S. No	Name of the Drug	Tamil name	Scientific Name	Parts used	Quantity
1	Angel's Trumphet	Ummathai	<i>Datura metel</i>	Leaf	3.5 Litre
2	Copper Sulfate	Thurusu	Copper Sulphate	Purified Salt	350g
3	Coconut oil	Thengai Ennai	<i>Cocos nucifera</i>	Oil	1.4 Litre





Subhashri et al.,

Table No 2. Organoleptic characters and Therapeutic uses of the Ingredients of Mathan Thailam: (7,1)

S.No	Ingredients	Scientific Name	Suvai	Actions	Therapeutic uses
1	Ummathai	<i>Datura metal</i>	Bitter (Kaippu)	<i>Vandhiundaki</i> (Emetic), <i>Esivagathri</i> (Antispastic), <i>Thuyaradaki</i> (Anodyne), <i>Moorchaiundaki</i> (Narcotic)	Ulcers, Abscess, various toxins, balances <i>Tirithodam</i>
2	Thurusu	Purified Copper Sulphate	Astringent ( <i>Thuvarppu</i> )	<i>Udalhetri</i> (Tonic), <i>Thuvarpi</i> (Astringent), <i>Vandhiundaki</i> (Emetic), <i>Azhugalagathri</i> (Antiseptic) & <i>Punundaki</i> (Caustic)	Ulcers, Eye diseases, Oral diseases, <i>Tirithodam</i> & Fever.
3	Thengai Ennai	<i>Cocos nucifera</i>	Sweet ( <i>Enippu</i> )	<i>Kulirchiundaki</i> (Refrigerant), <i>Udhaluramaki</i> (Tonic)	Burn wounds, Gum diseases, Fungal infections of skin & Scabies. Promotes Hair growth





## Shaping the English Language: The Influence of Sports Terminology

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### ABSTRACT

This research paper titled, “Shaping the English Language: The Influence of Sports Terminology”, explores the profound influence of sports terminology on the evolution of the English language. It traces the historical roots of sports-related language, from ancient games to modern global spectacles, demonstrating how it enriches vocabulary and contributes to linguistic dynamism. Sports terminology impacts syntax and grammar, shaping sentence structure and communication cadence. Idiomatic expressions from sports infuse daily discourse with vibrancy. This paper highlights the cultural impact of sports terminology, reflecting societal values and shifts. Contemporary global sports introduce linguistic diversity, revealing cultural interconnectedness. Media and technology, such as sports commentary and social media, disseminate sports language, illustrating modern communication’s influence on language evolution. Regional and community-specific sports terms enrich dialectal variations, embodying loyalty and identity. Language evolution theories, like lexical diffusion and sociolinguistic variation, apply to the impact of sports terminology. This research paper comprehensively examines the dynamic relationship between sports and language, showcasing the adaptability and resilience of the English language. It celebrates the enduring connection between sports and language, each term and phrase reflecting the vibrant tapestry of human experience and expression.

**Keywords:** Sports Terminology, English Language and Sports Communication, Dialectical Variations, Idiomatic Expressions in Sports



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## INTRODUCTION

Language, as a dynamic and living entity, continually evolves, shaped by the influences of culture, technology, and human interaction. One fascinating aspect of this linguistic evolution is the profound impact of specialized vocabularies developed in various domains, and among these, sports terminology stands as a prominent exemplar. The English language, in particular, has witnessed a remarkable transformation over the years, influenced not only by the natural progression of communication but also by the infusion of athletic jargon. The research paper, "Shaping the English Language: The Influence of Sports Terminology", embarks on a journey through the annals of the English language to explore the intricate relationship between sports terminology and its profound influence on language evolution. Sports, often seen as a microcosm of societal dynamics and aspirations, have introduced a rich tapestry of terms, idioms, and expressions that have seamlessly integrated into everyday discourse. They reflect not only the spirit of competition and athleticism but also the cultural, technological, and global changes that have defined various epochs. The historical context offers an entrancing narrative of the development of sports terminology, originating from archaic and diverse athletic pursuits to the global sporting spectacles we witness today. Through this historical lens, we can trace the transformation of language from the days of yore to the contemporary era, all the while recognizing the indomitable spirit of adaptability intrinsic to English. As we delve into this exploration, we will uncover how the influence of sports terminology transcends mere lexicon. It has altered the very syntax and grammar of the English language, infusing it with vivacity, colour, and an unmistakable sporting vibrancy. Furthermore, these terminologies bear the indelible imprints of cultural shifts and societal changes, offering a unique lens through which we can dissect the values and evolutions of different eras. In the digital age, the global village we inhabit has brought sports terminology to the farthest reaches, catalysing a linguistic globalization, resulting in dialectal variations that beg exploration.

### Historical Perspective

To appreciate the profound influence of sports terminology on the evolution of the English language, it is crucial to embark on a journey back in time, tracing the roots of athletic lexicon and its transformation into an integral part of everyday speech. The historical evolution of sports terminology in English can be divided into distinct phases, each marked by its unique set of linguistic contributions. The origins of many sports terms can be found in the ancient games and competitions of various cultures. Words such as "stadium," originating from the Greek "Stade," and "marathon," harking back to the legendary run of Pheidippides, provide a glimpse into the linguistic legacy of ancient athleticism. Moving forward in time, the Middle Ages was marked by tournaments, jousts, and archaic ball games. Terms such as "tournament" and "joust" entered the English language during this era, bearing witness to the chivalric values of the time. The Renaissance period witnessed a revival of classical knowledge, and this intellectual awakening found expression in sports as well. Words like "athlete," derived from the Greek "athlētēs," and "gymnasium," a reference to the Greek places of physical and intellectual exercise, began to permeate the lexicon. The advent of the modern Olympic Games in the late 19th century marked a significant juncture. The terminologies associated with various Olympic sports, from "athletics" to "gymnastics," found a permanent place in everyday conversation. The 20th and 21st Centuries mark the exponential growth of global sporting events, from the World Cup to the Olympics to the Super Bowl. Phrases like "photo finish," "home run," "fast break", "power play" and "slam dunk" became metaphorical expressions for various aspects of life. Lakoff and Turner claimed, "metaphors have the power of entailments that put in order our experience and form essential realities." (127). The advent of televised sports brought these terms into living rooms across the world, reinforcing their assimilation into daily language. It is evident that sports terminology has been a resilient traveller across centuries, adapting to the changing landscapes of culture and competition.

### Borrowings and Adaptations

The dynamic nature of language is not solely evident in the creation of new words but also in its capacity to borrow and adapt terms from various sources, including the rich lexicon of sports. Sports terminology has, over the years,



**Hitesh D Raviya and Deepali D Shahdadpuri**

offered a trove of words and phrases that seamlessly integrated into the everyday vernacular of the English language. One notable aspect of this integration is the process of direct borrowing. Sports-related terms, often possessing a vivid and evocative nature, are readily assimilated into everyday conversation. Consider the example of the term “touchdown,” borrowed directly from American football. This term’s adaptability lies in its expressive power, symbolizing not only a physical act on the field but also metaphorically signifying success in various aspects of life. Such direct borrowings are emblematic of the influence of sports on language evolution. The adaptability of sports terminology is particularly evident when it comes to metaphoric usage. Many terms that were originally specific to particular sports have been adapted to convey broader meanings. For instance, the term “home run” from baseball, originally describing a specific type of hit, is now used to indicate a resounding success or achievement in any field, from business to personal accomplishments. This adaptation of terminology transcends the boundaries of sports, illustrating how specialized vocabulary can enrich the expressiveness of a language. Furthermore, idioms and phrases rooted in sports have found their way into daily communication too.

A list of some common idioms and phrases is mentioned in the below table: The process of borrowing and adapting sports terminology is not confined to any specific time or place. It is an ongoing process, constantly refreshed by the introduction of new sports, the development of innovative techniques, and the emergence of cultural phenomena. As the world of sports continues to evolve, so too does the linguistic landscape, ensuring that the English language remains a vibrant reflection of contemporary human experiences. Sports terminology also plays a role in the establishment of idiomatic expressions, which can significantly affect sentence structure. For instance, the idiom “a home run” not only influences the words used but also the syntactic structure of a sentence, allowing for expressions like “She hit a home run with her presentation.” The influence of sports terminology is not just in individual terms but in the structures and patterns they create in language. One of the most apparent ways in which sports terminology affects syntax is through the formation of compound words and phrases. Sports, by nature, are a breeding ground for compound terms, as they require precision and conciseness. Phrases like “fast break,” “power play,” and “full-court press” exemplify this phenomenon. These compound expressions not only serve the purpose of conveying complex ideas succinctly in the realm of sports but have also influenced the structure of everyday language. English speakers have adapted to constructing compound phrases, conveying multiple concepts with remarkable efficiency.

**Cultural Impact**

Sports, as a reflection of society’s values and aspirations, carry within them the potential to shape culture and language. The influence of sports terminology on the English language transcends mere linguistic adaptations; it also offers a compelling lens through which we can dissect cultural shifts, societal norms, and the evolution of different eras. One of the most notable aspects of the cultural impact of sports terminology is its ability to encapsulate the values and priorities of specific times and places. Consider the lexicon of early cricket, a sport steeped in tradition and gentlemanly conduct. Boyle, R. and Haynes also states that, racism has been a large part of sporting culture,” (108). Terms like “gentleman’s game” or “fair play” not only describe the sport but also embody a cultural ideal of sportsmanship and decorum. As society evolves, so does the cultural ethos embedded in sports terminology. The rise of professional sports in the late 19th and early 20th centuries brought forth a new set of expressions, emphasizing competitiveness, athleticism, and commercialization. Phrases such as “level playing field” or “big league” not only denote aspects of competition but reflect the changing values and aspirations of the modern world. The interplay between sports terminology and culture becomes especially evident in the context of social movements and changes. The language of sports can serve as a mirror to societal developments. For example, the emergence of gender-inclusive terminology like “athlete” instead of “sportswoman” or “sportsman” reflects the progress of gender equality and inclusivity. “Boxing as an ‘iconic embodiment of masculinity’ can tell us much about the ‘representations of the masculine body and their psychic underpinnings’ (Jefferson, 78–79). Jefferson also notes that boxers, in particular Mike Tyson, came to be identified with a level of ‘hardness’, in terms of both mental and physical toughness.” (Boyle, R. and Haynes, R.: 139). The cultural impact of sports terminology is a testament to language’s ability to mirror and absorb the values and dynamics of society. It serves as a remarkable indicator of the cultural changes and progressions that define different epochs.







Hitesh D Raviya and Deepali D Shahdadpuri

### Media and Communication

The realm of media and communication plays a pivotal role in the dissemination, popularization, and perpetuation of sports terminology within the English language. Bernstein and Blain suggested, "The study of the ways in which media and sport interact crosses boundaries and can be found in literature concerned with the sociology of sport, history of sport, gender studies, cultural studies, journalism, leisure studies and beyond..." (01). Through broadcasts, print journalism, and digital platforms, the terminology of sports transcends stadiums and fields, enriching the language and connecting a global audience. One of the primary ways in which sports terminology influences the English language is through sports commentary. Commentators, often described as the "voice of the game," wield immense linguistic influence. Their descriptive narratives and expressions serve not only to convey the events on the field but also to immerse the audience in the action. The rapid, colorful language used by sports commentators can impact not only vocabulary but also the cadence and rhythm of spoken language. Phrases such as "buzzer-beater" or "photo finish" become part of the linguistic tapestry, resonating in everyday conversation.

Beyond commentary, sports journalism also plays a pivotal role. The choice of words and the narrative styles employed in sports reporting are notable for their vividness and immediacy. Journalistic language often employs present tense, even when discussing past events, creating a sense of immediacy and excitement. This grammatical choice, driven by the need to engage and captivate readers, finds its way into broader journalistic discourse and spoken language. Digital media, including social platforms and online forums, further amplify the reach of sports terminology. Fans and enthusiasts participate in the ongoing development of sports-related vocabulary. Phrases coined by fans, such as "three-peat" or "the GOAT," gain currency through online communities and permeate everyday conversations. Thus, "Televised sport not only provides our main connection to sport itself, but also our ideas about nationality, class, race, gender, age and disability. It therefore presents a rich seam of material from which to investigate and understand our social, cultural, economic and political lives." (Boyle, R. and Haynes, R.: 09). Moreover, the internationalization of sports, aided by media globalization, introduces linguistic diversity. As English serves as the lingua franca of international sports, terms from various languages and cultures infiltrate the English lexicon. Phrases like "hat-trick" from cricket, "judo" from Japanese, or "golazo" from Spanish are now integral to English sports discourse.

### Dialectical Variations

As sports terminology weaves its way into the fabric of the English language, it encounters the diverse linguistic landscapes of regions and communities. Dialectical variations, often influenced by local sporting cultures and preferences, contribute to the rich and dynamic nature of the English language. Regional dialects and accents are often accompanied by unique sports terminology. For example, the terminology associated with American football varies from region to region within the United States. Terms like "touchdown" and "field goal" remain consistent, but nuances in pronunciation and colloquialisms create distinctive variations. The same sport may be referred to as "gridiron football" in some regions while simply "football" in others, reflecting the intricate web of local language. In the context of dialectical variations, one cannot overlook the influence of beloved regional sports. Baseball in the United States, cricket in the Caribbean, rugby in New Zealand, and soccer (football) in the United Kingdom have all contributed to localized lexicons. These terms often reflect the unique cultural significance and prominence of these sports in various regions. For instance, the language of cricket in the Caribbean may incorporate local idioms, and the vocabulary of rugby in New Zealand may include Māori words and phrases. Additionally, international sports events, such as the Olympics or the World Cup, introduce linguistic variations. The terminology used to describe sports and events in these global spectacles reflects the diverse origins of athletes and fans. The fusion of terms from different languages, including Spanish, French, Japanese, and others, can result in dialectical variations within English-speaking communities. Thus, the same sport, with its unique terminology, may be celebrated or disparaged depending on one's geographical allegiance.







**Hitesh D Raviya and Deepali D Shahdadpuri**

## CONCLUSION

The impact of sports terminology on the English language is a testament to language’s remarkable adaptability and the continuous evolution of communication. This research paper has delved into the intricate relationship between the lexicon of sports and the broader landscape of English, revealing a complex interplay of influences that enrich the language. Sports terminology, with its historical roots and dynamic evolution, has proven to be a resilient traveller through time. It seamlessly integrates into everyday conversation, contributing to the ever-expanding vocabulary of English. The borrowings, adaptations, and metaphoric extensions of sports terminology infuse the language with vibrancy and colour, shaping the way we express ourselves and view the world. Culturally, sports terminology serves as a mirror to societal values and changes. It reflects the ideals and norms of different eras, echoing the shifts in human aspirations and expectations. Sports have their unique cultural significance and prominence, and the language they introduce reflects the diversity and dynamism of cultures around the world. The media and technology, with their power to broadcast and disseminate sports events, play a pivotal role in popularizing and perpetuating sports terminology. The instantaneous and global reach of modern media introduces linguistic diversity and universality, as phrases and terms traverse borders and boundaries. Dialectical variations within the English language are enriched by regional and community-specific sports terminologies. The regional differences, often rooted in local sporting cultures, offer a fascinating dimension of linguistic diversity, embodying the spirit of loyalty and identity. Moreover, sports terminology is not immune to the influence of language evolution theories. Lexical diffusion, language contact, sociolinguistic variation, and cultural linguistics all contribute to the dynamic relationship between sports and language. As sports become global phenomena, the interconnectedness of cultures accelerates the evolution of the English language. The impact of sports terminology on the English language is a vivid illustration of how language is a living, breathing entity, forever evolving to reflect the dynamic nature of human expression.

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Idioms	Sports	Implied Meaning
Play hardball	Baseball	It refers to the regular baseball as opposed to a “softball.”
Behind the eight ball	Billiards and Pool	Being behind the “eight ball” means you have a difficult shot ahead.
On a sticky wicket	Cricket	In a difficult or uncertain situation. It comes from the condition of a





**Hitesh D Raviya and Deepali D Shahdadpuri**

		cricket pitch affected by dampness or wear
Keep a straight bat	Cricket	To act honestly or fairly.
The ball is in your court	Tennis	Each player’s turn to serve is like having the “ball in their court.” It is your turn.
Touchdown	Football	It signifies a significant achievement or success.





## On Ternary Quadratic Diophantine Equation $2(x^2 + y^2) - xy = 57z^2$

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### ABSTRACT

The Ternary homogeneous second-degree equation given by  $2(x^2 + y^2) - xy = 57z^2$  Representing a cone is investigated to its non – zero integer solutions. A few pleasing relations betwixt the solutions and special integer are obtained.

**Keywords:** Ternary second-degree integer solutions, homogeneous quadratic.

## INTRODUCTION

The Diophantine equations provide unbounded fields for research due to their variety [1-3]. In particular, one may cite [4-21] for quadratic equation with three unspecified. This communications concern with yet another interesting homogeneous quadratic equation with three unknowns  $2(x^2 + y^2) - xy = 57z^2$  for ascertaining its infinitely many non – zero integral points. Also, a few fascinating relations among the solutions are exhibite





**Radhika et al.,**

**NOTATION USED**

1.  $t_{m,n}$  = Polygonal integer of order n with size m
2.  $P_n^m$  = pyramidal integer of order n with size m
3.  $P_r^n$  = pronic integer of order n
4.  $So_n$  = Stella octangular integer of order n
5.  $j_n$  = Jacobsthallucas integer of order n
6.  $J_n$  = Jacobsthal integer of order n
7.  $Gno_n$  = Gnomonic integer of order n
8.  $M_n$  = Mersenne integer of order n
9.  $HG_n$  = Hexagonal integer of order n
10.  $PP_n$  = Pentagonal pyramidal integer of order n
11.  $SP_n$  = Square pyramidal integer of order n
12.  $OH_n$  = Octohedral integer of order n
13.  $FN_n^4$  = Four dimensional figurate integer whose generating polygonal is a square

**METHOD OF ANALYSIS**

The Second degree Diophantine equation with three unknowns to be solved for obtaining non-zero integral solution is

$$2(x^2+y^2) -xy=57z^2 \quad \dots\dots\dots (1)$$

The substitution of linear transformations

$$\left. \begin{aligned} x &= u + 3v \\ y &= u - 3v, u \neq v \neq 0 \end{aligned} \right\} \dots\dots\dots (2)$$

In (1) gives

$$u^2 + 15v^2 = 19z^2 \quad \dots\dots\dots (3)$$

Assume that

$$z = (a, b) = a^2 + 15b^2, a, b \neq 0 \quad \dots\dots\dots (4)$$

**PATTERN 1:**

$$19 = (2+i\sqrt{15})(2-i\sqrt{15}) \quad \dots\dots\dots (5)$$

Substituting (4) and (5) in (3) we get,

$$(u+i\sqrt{15}v)(u-i\sqrt{15}v) = (2+i\sqrt{15})(2-i\sqrt{15})(a+i\sqrt{15}b)^2(a-i\sqrt{15}b)^2$$

Equating the positive and negative factors we get,

$$(u+i\sqrt{15}v) = (2+i\sqrt{15})(a+i\sqrt{15}b)^2 \quad \dots\dots\dots (6)$$

$$(u+i\sqrt{15}v) = (2-i\sqrt{15})(a-i\sqrt{15}b)^2 \quad \dots\dots\dots (7)$$





**Radhika et al.,**

Equating the real and imaginary parts in either (6) or (7) we get,

$$u=2a^2- 30b^2-30ab \dots\dots\dots(8)$$

$$v=a^2-15b^2+4ab \dots\dots\dots (9)$$

Substituting (8) and (9) in (2) we get,

$$x=5a^2- 75b^2- 18ab \dots\dots\dots (10)$$

$$y=-a^2+15b^2-42ab \dots\dots\dots (11)$$

**Properties:**

1.  $(a, a+1) + 70T_4 + 18Pr_a \equiv 75 \pmod{150}$
2.  $(a, 3a-2) + 670T_4 + 18T_{8,a} \equiv 300 \pmod{900}$
3.  $(a^2, a+1) + T_4 - 13T_{4,a} + CS_a + 84PP_a \equiv 14 \pmod{28}$
4.  $(a, 4a-3) - 239T_4 + 42T_{10,a} \equiv 135 \pmod{360}$
5.  $(a+1, a-1) - 14T_4 + CS_a \equiv 15 \pmod{30}$
6.  $(a, 12a-11) - CH_3 - 2158T_4 \equiv \pmod{3957}$
7.  $(a, a) = 16a^2, a \text{ Perfectsquare}$
8.  $(a, -a) = -60a^2, \text{ anartynumber}$
9.  $2[(a, ) + (a, a)] = -24a^2 \text{ anartynumber}$
10.  $(a, 1) + (a, 1) + z(a, 1) - 5T_{4,a} \equiv 60 \pmod{60}$

**Pattern 2:**

The ternary quadratic equation (3) can be written as

$$u^2-4z^2=15(z^2-v^2) \dots\dots\dots (12)$$

Factorizing(12)we have

$$(u+ 2z) (u-2z)=15z+ v)(z-v) \dots\dots\dots (13)$$

$$\frac{u+2z}{15(z+v)} = \frac{z-v}{u-2z} = \frac{A}{B}, B \neq 0 \dots\dots\dots(14)$$

This is equivalent to the following two equations

$$(2B -15A)z +Bu-15Av=0 \dots\dots\dots (15)$$





**Radhika et al.,**

$$(B+2A)z - Au + Bv = 0 \quad \dots\dots\dots (16)$$

Applying the method of cross multiplication, we get

$$z = A^2 + 15B^2 \quad \dots\dots\dots (17)$$

$$u = -30A^2 - 2B^2 - 30AB \quad \dots\dots\dots (18)$$

$$v = 15A^2 - B^2 - 4AB \quad \dots\dots\dots (19)$$

Substituting (18) and (19) in (2) we get

$$X = 15A^2 - B^2 - 42AB \quad \dots\dots\dots (20)$$

$$Y = -75A^2 + 5B^2 - 18A \quad \dots\dots\dots (21)$$

**Properties:**

1.  $(a, 12a - 11) + 129T_4 + 42T_{2b, a} \equiv 121 \pmod{264}$
2.  $(a, 2a^2 - 1) + 95T_4 - 20T_{4, a^2} + 18S_{0a} - J_4 = 0$
3.  $(a, 3a - 2) - CH_3 - 133T_4 \equiv 59 \pmod{177}$
4.  $(a, a) + 2(a, a) = 40a^2$  a perfect square
5.  $(a, a + (a, a)) = -96a^2$ , a narty number

**Case (i)**

Equation (13) can be written as

$$\frac{u + 2z}{15(z - v)} = \frac{z + v}{u - 2z} = \frac{A}{B}, B \neq 0$$

This is equivalent to the following two equations

$$(2B - 15A)z + Bu + 15Av = 0 \quad \dots\dots\dots (22)$$

$$(B + 2A)z - Au + Bv = 0 \quad \dots\dots\dots (23)$$

Applying the method of cross multiplication, we get

$$z = (A, B) = A^2 + 15B^2 \quad \dots\dots\dots (24)$$

$$u = (A, B) = 30A^2 - 2B^2 + 30AB \quad \dots\dots\dots (25)$$

$$v = (A, B) = 15A^2 - B^2 - 4AB \quad \dots\dots\dots (26)$$

We get

$$x = 75A^2 - 5B^2 + 18AB \quad \dots\dots\dots (27)$$

$$y = -15A^2 + B^2 + 42AB \quad \dots\dots\dots (28)$$







**Radhika et al.,**

**Properties:**

1.  $(a, 7a - 6) + 170T_4, -T_{16, a} \equiv 180 \pmod{420}$
2.  $(a, a + 1) + 14T_4, -42Pr_a \equiv 1 \pmod{2}$
3.  $(a^2, a + 1) - T_{4, 2} - CS_a - 13T_{4, a} \equiv 14 \pmod{28}$
4.  $(a, a) + 2(a, a) = 144$  a Perfect square
5.  $6((a, a)) = 96a^2$ , a nasty number .

**PATTERN 3:**

The ternary quadratic equation (3) can be expressed as

$$u^2 = 19z^2 - 15v^2 \dots\dots\dots (29)$$

Consider the linear transformation

$$\left. \begin{aligned} Z &= x + 15T \\ V &= x + 19T \end{aligned} \right\} \dots\dots\dots (30)$$

(OR)

$$\left. \begin{aligned} Z &= x - 15T \\ V &= x - 19T \end{aligned} \right\} \dots\dots\dots (31)$$

Substituting (30) or (31) in (29) we get

$$u^2 = 4(X^2 - 285T^2) \dots\dots\dots (32)$$

$$\text{Written } u = 4U \dots\dots\dots (33)$$

Substituting (33) in (32), we get

$$X^2 = U^2 + 285T^2 \dots\dots\dots (34)$$

This is in the standard form

$$x^2 = Dy^2 + z^2$$

This the corresponding solutions to (34) are

$$T = 2AB \dots\dots\dots (35)$$

$$U = 285A^2 - B^2 \dots\dots\dots (36)$$

$$X = 285A^2 + B^2 \dots\dots\dots (37)$$

Substituting (36) in (33) we have

$$\begin{aligned} u &= 4(285A^2 - B^2) \\ U &= 570A^2 - 2B^2 \dots\dots\dots (38) \end{aligned}$$





**Radhika et al.,**

**Case (i)**

Substituting (35) and (37) in (30) we get

$$Z = 285A^2 + B^2 + 30AB \dots\dots\dots(39)$$

$$V = 285A^2 + B^2 + 38AB \dots\dots\dots (40)$$

(38) and (40) in (2) we get

$$x = 1425A^2 + B^2 + 114AB \dots\dots\dots (41)$$

$$y = -285A^2 - 5B^2 - 114AB \dots\dots\dots(42)$$

**Properties:**

1.  $(a, 8a-7) - CH_3 - 1486T_{4,a} - 114T_{18,a} \equiv 48 \pmod{109}$
2.  $(a, 6a-5) + 465T_{4,a} + 114T_{4,a} \equiv 125 \pmod{465}$
3.  $(a, 15a-13) - 510T_{4,a} + 30T_{17,a} \equiv 169 \pmod{390}$
4.  $(1, a) + 5T_{4,a} \equiv 285 \pmod{114}$
5.  $(a, a+1) - 284T_{4,a} - CS_a - 60Pr_a = 0$

**Case (ii)**

Substituting (35) and (37) in (31) we get

$$Z = 285A^2 + B^2 - 30AB \dots\dots\dots (43)$$

$$V = 285A^2 + B^2 - 38AB \dots\dots\dots (44)$$

(38) and (44) in (2) we get

$$x = (A, B) = 1425A^2 + B^2 - 114AB \dots\dots\dots (45)$$

$$y = (A, B) = -285A^2 - 5B^2 + 114AB \dots\dots\dots(46)$$

**Property:**

1.  $(a, a+1) - CS_a - 1424T_{4,a} + 114Pr_a = 0$
2.  $(a^2, a^2-1) + 290T_{4,a}^2 - 10T_{4,a} + J_4 - 1368FN_{a^4} = 0$
3.  $(a, 4a-3) - CH_3 - 298T_{4,a} + 30T_{4,a} \equiv 8 \pmod{21}$
4.  $(a, a) = 256a^2$  a perfect square
5.  $2(a, a) + (a, a) = -96a^2$ , a nasty number





**Radhika et al.,**

**PATTERN 4:**

The ternary quadratic equation(34)can be written as

$$X^2-U^2=285T^2 \dots\dots\dots(47)$$

Employing the method of factorization we have

$$(X+U) (X-U) =(285T)$$

Equating the positive and negative factors, we get

$$X+U=285T \dots\dots\dots(48)$$

$$X+U=285T \dots\dots\dots(49)$$

Solving (41) and (42) we get

$$X=143T \dots\dots\dots(50)$$

$$U=142T \dots\dots\dots(51)$$

Substituting (33) in (51) we get

$$U=2(142T)$$

$$U=284T$$

$$\text{For } T=A \dots\dots\dots(52)$$

We get

**Case i:**

$$X=143A \dots\dots\dots(53)$$

$$U=284A \dots\dots\dots(54)$$

Substituting (54) and (53) in (30) we get

$$Z=158A \dots\dots\dots(55)$$

$$V=162A \dots\dots\dots(56)$$

Substituting (54) and(56) in (2),we get

$$x=770A \dots\dots\dots(57)$$

$$=-202A \dots\dots\dots(58)$$





**Radhika et al.,**

**Properties:**

1.  $(a^2)+(a^2)+z(a^2)-726T_{4,a}=0$
2.  $(a)+(a) +z(a)\equiv 0(mod726)$
3.  $(2a-1)\equiv 770(mod1540)$
4.  $(a^2) +202T_{4,a}=0$
5.  $(2a^2+1)-T_{4,-158}=0$

**Case (ii)**

Substituting (52) and (53) in (31) we get

$$Z=128A \dots\dots\dots(59)$$

$$V=124A \dots\dots\dots(60)$$

Substituting (54) and (60) in (2), we get

$$x=656A \dots\dots\dots(61)$$

$$y=-88A \dots\dots\dots(62)$$

**Properties:**

1.  $2(a^2) =256a^2$  *aperfectsquare*
2.  $3[(a^2) + (a^2)] =120a^2$  *anartynumber*
3.  $(a^2) -2(a^2) = 400a^2$  *aperfectsquare*
4.  $4[(a^3)] =512a^2$  *aperfectsquare*
5.  $(a)+(a) +z(a)\equiv 0(mod726)$

**PATTERN 5:**

Equation (47) can be written as

$$(X+U)(X-U)=(285)^2$$

Equating the positive and negative factors , we get

$$X+U=T^2 \dots\dots\dots(63)$$

$$X-U=285 \dots\dots\dots(64)$$

Solving (63) and(64)we get

$$U = \frac{T^2+285}{2} \dots\dots\dots (65)$$

$$U = \frac{T^2-285}{2} \dots\dots\dots (66)$$





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As our interest is on finding integer solutions, choose  $T$  so that  $X$  and  $U$  are integers

write  $T=2A+1$  .....(67)

Substituting (67) in (65) and (66)

$$X=2A^2+2A+143 \quad \dots\dots\dots (68)$$

$$U=2A^2+2A-142 \quad \dots\dots\dots (69)$$

Substituting(69)in(33),we get

$$U=4A^2+4A-284 \quad \dots\dots\dots (70)$$

**Case i**

Substituting (67) and (68) in (30), we get

$$Z =2A^2+32A+158 \quad \dots\dots\dots (71)$$

$$V =2A^2+40A+162 \quad \dots\dots\dots (72)$$

Substituting (70) and (72) in (2) we get

$$x=10A^2+124A+ 202 \quad \dots\dots\dots (73)$$

$$y=-2A^2-116A-770 \quad \dots\dots\dots (74)$$

**Properties:**

1.  $(a^2)+ 120FN_a^4+114T_4=202$
2.  $(2a-1) -40T_4\equiv 202(mod 208)$
3.  $(2a^2- 1)+96FN_a^4+232T_4+662=0$
4.  $(a+1) +2T_4\equiv 888(mod 120)$
5.  $(a-1)-2T_4\equiv 128(mod 28)$

**Case ii**

Substituting (67) and (68) in (31),we get

$$Z=2A^2-28A+128 \quad \dots\dots\dots (75)$$

$$V=2A^2-36A+124 \quad \dots\dots\dots (76)$$

Substituting (70) and (76) in (2), we get

$$x=10A^2-104A+88 \quad \dots\dots\dots (77)$$

$$y=-2A^2+112A-656 \quad \dots\dots\dots (78)$$





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**Properties:**

1.  $x(a) + y(a) + z(a) - 10T_{4,a} = 440 \pmod{20}$
2.  $x(2a) - 40T_{4,a} = 88 \pmod{208}$
3.  $y(a^2) + 24FN_{a^4} - 110T_{4,a} + 656 = 0$
4.  $y(2a) + 8T_{4,a} = 656 \pmod{224}$
5.  $z(a) - 2T_{4,a} = 128 \pmod{28}$

**PATTERN 6:**

Equation (47) can be written as

$$(X+U)(X-U) = (19T)(15T)$$

This is equivalent to the following two equations

$$BX + BU - 19AT = 0 \dots\dots\dots(80)$$

$$-AX + AU + 15BT = 0 \dots\dots\dots(81)$$

Applying the method of cross multiplication, we get

$$T = 2AB \dots\dots\dots(82)$$

$$X = 19A^2 + 15B^2 \dots\dots\dots(83)$$

$$U = 19A^2 - 15B^2 \dots\dots\dots(84)$$

Substituting (84) in (33)

$$U = 38A^2 - 30B^2 \dots\dots\dots(85)$$

Substituting (82) and (83) in (30), we get

$$Z = 19A^2 + 15B^2 + 30AB \dots\dots\dots(86)$$

$$V = 19A^2 + 15B^2 + 38 \dots\dots\dots(87)$$

Substituting (85) and (87) in (2) we get

$$x = 95A^2 + 15B^2 + 114AB \dots\dots\dots(88)$$

$$y = -19A^2 - 75B^2 - 114AB \dots\dots\dots(89)$$

**Properties:**

1.  $x(a, 9a-7) - 1310T_{4,a} - 228T_{11,a} = 735 \pmod{1890}$
2.  $y(a^2, a^2-1) - 131T_{4,a} + 75T_{4,a^2} + 1368FN_{a^4} + 75 = 0$
3.  $z(a, a) = 64a^2$  *aperfectsquare*
4.  $x(a, a) + y(a, a) = 16a^2$  *aperfectsquare*
5.  $x(a, 1) - 95T_{4,a} = 15 \pmod{114}$







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**Case ii**

Substituting (82) and (83) in (31), we get

$$Z = 19A^2 + 15B^2 - 30AB \dots\dots\dots(90)$$

$$V = 19A^2 + 15B^2 - 38AB \dots\dots\dots (91)$$

Substituting (85) and (91) in (2) we get

$$x = 95A^2 + 15B^2 - 114AB \dots\dots\dots (92)$$

$$y = -19A^2 - 75B^2 - 114AB \dots\dots\dots (93)$$

**Properties:**

1.  $z(a,a) = 4a^2$  a perfect square
2.  $y(a,a) + z(a,a) = 24a^2$  a stynumber
3.  $x(a,1) + y(a,1) - 76T_{4,a} + 60 = 0$
4.  $x(a,11a-9) - 1910T_{4,a} + 228T_{13,a} \equiv 1215 \pmod{2970}$
5.  $z(a,a+1) - 34T_{4,a} + 30Pr_a \equiv 15 \pmod{30}$

**PATTERN 7:**

Equation (47) can be written as

$$(X+U)(X-U) = 19(15T^2) \dots\dots\dots (94)$$

Equating the positive and negative factors, we get

$$X+U=19 \dots\dots\dots(95)$$

$$X-U=15T^2 \dots\dots\dots(96)$$

Solving (95) and (96), we get

$$X = \frac{19+15T^2}{2} \dots\dots\dots(97)$$

$$X = \frac{19-15T^2}{2} \dots\dots\dots(98)$$

As our interest is on finding integer solutions, choose  $T$  so that  $X$  and  $U$  are integers

Write  $T = 2A + 1 \dots\dots\dots(99)$

Substituting (99) in (97) and (98), we get

$$X = 30A^2 + 30A + 17 \dots\dots\dots(100)$$

$$U = -30A^2 - 30A + 2 \dots\dots\dots(101)$$





**Radhika et al.,**

Substituting (101) in (33), we get

$$U = -60A^2 - 60A + 4 \dots\dots\dots(102)$$

**Case i**

Substituting (99) and (100) in (30), we get

$$Z = 30A^2 + 60A + 32 \dots\dots\dots(103)$$

$$V = 30A^2 + 68A + 36 \dots\dots\dots (104)$$

Substituting (102) and (104) in (2) we get

$$x = 30A^2 + 144A + 112 \dots\dots\dots(105)$$

$$y = -150A^2 - 264A - 104 \dots\dots\dots (106)$$

**Properties:**

1.  $x(a^2) - 30T_{4,a^2} - 112 = 144a^2$  a perfect square
2.  $z(a^2) - 30T_{4,a^2} - 32 = 60a^2$  a nartyn umber
3.  $x(a^2 - 1) - 30T_{4,a^2} - 32 = -54a^2$  a narty number
4.  $y(2a) + 300T_{4,a} \equiv 104 \pmod{528}$
5.  $y(2a - 1) + 600T_{4,a} \equiv 10 \pmod{72}$

**Case (ii)**

Substituting (99) and (100) in (31), we get

$$Z = 30A^2 + 2 \dots\dots\dots(107)$$

$$V = 30A^2 - 8A - 2 \dots\dots\dots (108)$$

Substituting (102) and (108) in (2) we get

$$x = 30A^2 - 84A - 2 \dots\dots\dots (109)$$

$$y = -150A^2 - 36A + 10 \dots\dots\dots(110)$$

**Properties :**

1.  $(a^2) - 30T_{4,a^2} - 84T_{4,a} - 2 = 0$
2.  $(a+1) - 30T_{4,a} \equiv 56 \pmod{24}$
3.  $(2a^2 - 1) + 7200FN_a^4 + 72a^2 - 104 = 0$
4.  $y(2a^2) + 600T_{4,a^2} + 72T_{4,a} - 30 = 0$
5.  $z(a) - 2 = 30a^2$ , anastynumber





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**PATTERN 8:**

(47) can be written as

$$(X+U)(X-U)=(19T^2)15$$

Equating the positive and negative factors, we get

$$X+U=19T^2 \dots\dots\dots(111)$$

$$X-U=15 \dots\dots\dots(112)$$

Solving (111) and (112), we get

$$x = \frac{19T^2+15}{2} \dots\dots\dots(113)$$

$$x = \frac{19T^2-15}{2} \dots\dots\dots(114)$$

As our interest is on finding integer solutions, choose  $T$  so that  $X$  and  $U$  are integers

Write  $T=2A+1 \dots\dots\dots(115)$

Substituting (115) in (113) and (114), we get

$$X=38A^2+38A+17 \dots\dots\dots(116)$$

$$U=38A^2+38+2 \dots\dots\dots(117)$$

Substituting (117) in (33), we get

$$U=76A^2+76A+4 \dots\dots\dots(118)$$

**Case (i)**

Substituting (115) and (116) in (30), we get

$$Z=38A^2+68A+32 \dots\dots\dots(119)$$

$$V=38A^2+76A+36 \dots\dots\dots(120)$$

Substituting (118) and (120) in (2) we get

$$x=190A^2+304A+112 \dots\dots\dots(121)$$

$$y=-38A^2-152A-104 \dots\dots\dots(122)$$

**Properties:**

1.  $x(2a)-760T_{4,a} \equiv 112 \pmod{608}$
2.  $x(a)+y(a)+z(a)-190T_{4,a} \equiv 40 \pmod{220}$
3.  $x(a^2)-190T_{4,a^2}-304T_{4,a} \equiv 112$
4.  $z(2a)-152T_{3,a} \equiv 32 \pmod{136}$
5.  $y(a)+38T_{4,a} \equiv 104 \pmod{152}$

**Case (ii)**

Substituting (115) and (116) in (31), we get

$$Z=30A^2+8A+2 \dots\dots\dots(123)$$

$$V=38A^2-2 \dots\dots\dots(124)$$





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Substituting (118) and (124) in (2) we get

$$x = 190A^2 + 76A - 2 \dots\dots\dots (125)$$

$$y = -38A^2 + 76A + 10 \dots\dots\dots (126)$$

**Properties:**

1.  $(2a-1) - 760T_4 \equiv 112 \pmod{608}$
2.  $(a+1) - 190T_4 \equiv 264 \pmod{456}$
3.  $(-a) - 38T_4 \equiv 10 \pmod{76}$
4.  $(2a) - 152T_4 \equiv 2 \pmod{16}$
5.  $x(a^2) + y(a^2) + z(a^2) - 190T_{4,a^2} - 160T_{4,a} = 0$

**PATTERN 9:**

$$19 = \frac{(4n+2ni\sqrt{15})(4n-2ni\sqrt{15})}{4n^2} \dots\dots\dots (127)$$

Substituting (4) and (127) in (3) we get,

$$(u + i\sqrt{15}v)(u - i\sqrt{15}v) = \frac{(4n + 2ni\sqrt{15})(4n - 2ni\sqrt{15})}{4n^2} (a + i\sqrt{15}v)^2 (a - i\sqrt{15}v)^2$$

Equating the positive and negative factors we get

$$(u + i\sqrt{15}v) = \frac{(4n+2ni\sqrt{15})}{2n} (a + i\sqrt{15}v)^2 \dots\dots\dots (128)$$

$$(u - i\sqrt{15}v) = \frac{(4n-2ni\sqrt{15})}{2n} (a - i\sqrt{15}v)^2 \dots\dots\dots (129)$$

Equating the real and imaginary parts in either (128) or (129) we get,

$$u = 2a^2 - 30b^2 - 30ab \dots\dots\dots (130)$$

$$v = a^2 - 15b^2 + 4ab \dots\dots\dots (131)$$

Substituting (130) and (131) in (2) we get,

$$x = 5a^2 - 75b^2 - 18ab \dots\dots\dots (132)$$

$$y = -a^2 + 15b^2 - 42ab \dots\dots\dots (133)$$





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**Properties:**

1.  $x(a^2,a+1)-5T_{4,a^2}+75T_{4,a}+36P_a^5\equiv 75(mod150)$
2.  $x(a^2,2a-1)-5T_{4,a^2}+300T_{4,a}+36CP_a^6\equiv 75(mod150)$
3.  $y(a,7a-6)-734T_{4,a}-42T_{16,a}\equiv 540(mod1260)$
4.  $y(a,a^2)-12FN_a^4-T_{4,a^2}+42CP_a^6$
5.  $z(a,a)-16T_{4,a}=0$
6.  $z(a+1,a-1)-16T_{4,a}\equiv 16(mod18)$
7.  $y(a,1)+T_{4,a}\equiv 15(mod42)$
8.  $z(a+3,a-2)-CH_3+13T_{4,a}\equiv 28(mod24)$
9.  $z(2a,2a)=64a^2$  *aperfectsquare*
10.  $x(a,2a^2-1)-5T_{4,a}+3600FN_a^4+18SO_a=75$

**PATTERN 10:**

Equation (3) can be written as

$$u^2 + 15v^2 = 19z^2 * 1 \dots\dots\dots(134)$$

Write  $i = \frac{(n+ni\sqrt{15})(n-ni\sqrt{15})}{16n^2} \dots\dots\dots(135)$

Write  $19 = \frac{(4n+2ni\sqrt{15})(4n-2ni\sqrt{15})}{4n^2} \dots\dots\dots(136)$

Substituting (135), (136) and (4) in (134), we get

$$\begin{aligned} & (u + i\sqrt{15}v)(u + i\sqrt{15}v) \\ &= \frac{(4n + 2ni\sqrt{15})(4n - 2ni\sqrt{15})}{4n^2} \frac{(n + ni\sqrt{15})(n - ni\sqrt{15})}{16n^2} \end{aligned}$$

$$(a + i\sqrt{15}b)^2(a - i\sqrt{15}b)^2$$





**Radhika et al.,**

Equating the positive and negative factor we get

$$(u + i\sqrt{15}v) = \frac{(4n+2ni\sqrt{15})(n+ni\sqrt{15})}{2n \cdot 4n} (a + i\sqrt{15}b)^2 \dots\dots\dots(137)$$

$$(u - i\sqrt{15}v) = \frac{(4n-2ni\sqrt{15})(n-ni\sqrt{15})}{2n \cdot 4n} (a - i\sqrt{15}b)^2 \dots\dots\dots(138)$$

Equating the real and imaginary parts in either (137) or (138) we get,

$$u = \frac{1}{4} (-13a^2 + 195b^2 - 90ab) \dots\dots\dots(139)$$

$$v = \frac{1}{4} (3a^2 - 45b^2 - 26ab) \dots\dots\dots (140)$$

Substituting (139) and (140) in (2) we get,

$$x = \frac{1}{4} (-4a^2 + 60b^2 - 168ab) \dots\dots\dots(141)$$

$$y = \frac{1}{4} (-22a^2 + 330b^2 - 12ab) \dots\dots\dots(142)$$

Put a = 4A, b = 4B in (141) and (142)

$$x = -16A^2 + 240B^2 - 672AB \dots\dots\dots(143)$$

$$y = -88A^2 + 1320B^2 - 48AB \dots\dots\dots(144)$$

**Properties:**

1.  $x(A^2, A+1) + 16T_{4,A^2} - 240T_{4,A} + 1344PP_{aA} \equiv 240 \pmod{480}$
2.  $z(A^2, 2A-1) - 976T_{4,A} \equiv 240 \pmod{960}$
3.  $4(z(a, a)) = 1024A^2$ , a perfect square
4.  $x(A, A) + y(A, A) + z(A, A) - 1369T_{4,A} = 0$
5.  $(1, A) - 1320T_{4,A} \equiv 88 \pmod{48}$ .

**CONCLUSION**

In conclusion, one may study other methods of third degree equation with four unknowns and examine for their integer solutions.

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# Automated Brain Tumor Detection in MRI Images using Deep Learning Approach

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## ABSTRACT

Brain tumor segmentation plays a crucial role in the diagnosis, treatment planning, and monitoring of brain tumors. With the advent of deep learning techniques, automated segmentation methods have witnessed significant advancements, providing accurate and efficient solutions for analyzing MRI images. This survey paper aims to provide a comprehensive overview of recent advancements in deep learning-based automated brain tumor segmentation in MRI images. We discuss the key challenges in brain tumor segmentation, review the state-of-the-art deep learning models and architectures, highlight the available datasets, and present an analysis of evaluation metrics and performance comparisons. The survey concludes with an outlook on future research directions in this rapidly evolving field.

**Keywords:** Brain Tumor, Artificial Intelligence, Machine Learning, Deep Learning, CNN, Segmentation

## INTRODUCTION

Normal brain is made up of three types of soft tissues: gray matter (GM), white matter (WM), and cerebrospinal fluid (CSF)[1]. The brain is a complex organ that controls various bodily functions, including movement, sensation, thoughts, and emotions. When a tumor develops in the brain, it can interfere with these normal functions and lead to a wide range of symptoms depending on its size, location, and rate of growth. A brain tumor refers to an abnormal growth of cells in the brain. It can originate from brain tissue or may have spread from other parts of the body (known as secondary or metastatic brain tumors). Brain tumors can be either benign (non-cancerous) or malignant (cancerous)[2]. To diagnose a brain tumor, doctors may employ various techniques, such as neurological



**Dipti Mathpal and Nikhil Gondaliya**

exams, imaging tests (e.g., MRI, CT scan), and in some cases, a biopsy to analyze a sample of the tumor tissue. The classification of brain tumors is based on their cell type, location, and rate of growth.

**Background and Motivation**

Automated brain tumor segmentation in MRI images holds significant importance in clinical practice and research for several reasons:

**Accurate Diagnosis**

MRI is a common imaging modality used in brain tumor diagnosis. Automated segmentation enables precise delineation of tumor boundaries, facilitating accurate identification and characterization of tumor regions.

**Treatment Planning**

Accurate segmentation provides essential information for treatment planning. By identifying tumor regions, surgeons can determine the optimal surgical approach and plan the resection to minimize damage to healthy brain tissue.

**Monitoring Treatment Response**

Automated segmentation allows for the longitudinal assessment of tumor response to treatment. By comparing follow-up MRI images with baseline segmentation, healthcare professionals can quantify changes in tumor size, shape, and volume.

**Research and Clinical Trials**

Automated segmentation plays a vital role in brain tumor research and clinical trials. Accurate and reproducible tumor segmentation enables the evaluation of new treatment modalities, assessment of treatment response, and analysis of disease progression patterns.

**Time Efficiency**

Manual segmentation of brain tumors is a labor-intensive and time-consuming task. Automated segmentation techniques significantly reduce the time required for tumor delineation. Overall, automated brain tumor segmentation in MRI images is of great significance as it improves diagnostic accuracy, enables personalized treatment planning, facilitates treatment response monitoring, supports research endeavours, and enhances overall patient care.

**Magnetic Resonance Imaging**

MRI is a widely utilized imaging modality for brain tumor detection due to its dynamic and flexible nature, allowing for sufficient contrast in captured images. By using different pulse types and imaging parameters, the intensity of the images can be adjusted. For example, varying the imaging parameter related to longitudinal relaxation time produces T1-weighted images, while variation in transverse relaxation time generates images for the T2 modality. Tissue characteristics can be captured by modulating signal intensities in T1- and T2-weighted images[3]. The contrast of MRI images relies on the pulse parameters. MRI provides detailed structural information of the brain and is effective even in early stages of disease, particularly in detecting white matter that may not be captured by CT scans. The intensity of brain images is primarily determined by T1 and T2 relaxation times, which exhibit distinct contrasts in T1- and T2-weighted images. Some common artifacts in MRI images include partial volume, RF noise, intensity overlaps, motion, and gradient. MRI offers advantages such as excellent soft tissue visualization, high image resolution with 1-mm cubic voxels, and a high signal-to-noise ratio in the image cube.

MRI has certain drawbacks that need to be considered. Firstly, the acquisition time for MRI is generally longer compared to other imaging modalities such as CT. Additionally, achieving homogeneity in image intensity can be challenging in MRI. However, despite these disadvantages, the advantages of MRI outweigh them, making it a preferred modality for capturing brain images. Therefore, this chapter focuses on MR imaging-based methods for brain tumor segmentation. There are several challenges associated with automated or semi-automated brain tumor localization in MRI. Firstly, the origin of tumorous tissues can occur anywhere in the brain, posing a significant challenge in their localization. Secondly, normal brain tissues have predefined locations, but the growth of tumors can deform these tissues, making their identification more difficult. Moreover, different MRI sequences, including T1-weighted, T2-weighted, T1c, and fluid-attenuated inversion recovery (FLAIR), provide distinct biological



**Dipti Mathpal and Nikhil Gondaliya**

information about brain tissues [4]. Relying on only a subset of these sequences may not ensure accurate tumor detection. Finally, the accuracy of segmentation also influences the prediction of tumor growth rate, which is crucial for post-treatment planning.

**Brain Tumor Segmentation**

Brain tumor segmentation refers to the process of identifying and delineating tumor regions within medical imaging data, particularly magnetic resonance imaging (MRI) scans of the brain. It involves the use of computational algorithms and techniques to automatically analyze the images and segment the tumor regions. The segmentation of brain tumors is a crucial step in various aspects of clinical practice and research. It provides valuable information for accurate diagnosis, treatment planning, monitoring treatment response, and conducting clinical studies. Manual segmentation by radiologists can be time-consuming, subjective, and prone to inter-observer variability. Automated segmentation methods, particularly those based on deep learning techniques, have emerged as a promising approach to overcome these challenges. Deep learning-based approaches for brain tumor segmentation utilize neural networks, such as convolutional neural networks (CNNs), to learn the complex patterns and characteristics of brain tumors from large datasets [4]. These models can effectively capture the spatial relationships and variabilities of tumors, enabling accurate segmentation results. The process of brain tumor segmentation typically involves the following steps: 1. Pre-processing 2. Training 3. Testing 4. Post Processing [5]. Evaluation of the segmentation results is typically performed by comparing the automated segmentations with ground truth annotations created by expert radiologists. Various metrics, such as Dice coefficient, Jaccard index, or Hausdorff distance, are used to assess the accuracy and overlap between the automated and manual segmentations [6]. Accurate and robust brain tumor segmentation is crucial for guiding treatment decisions, monitoring disease progression, and conducting research studies. It enables precise tumor localization, quantitative analysis of tumor characteristics, and assessment of treatment response. By automating this process, deep learning-based segmentation methods offer the potential to enhance efficiency, reduce inter-observer variability, and improve patient outcomes in the management of brain tumors [7].

**Traditional and Emerging Techniques****Thresholding based techniques**

Thresholding-based techniques in brain tumor detection involve setting intensity thresholds on MRI images to separate tumor regions from the surrounding healthy tissue [21]. These methods use pixel intensity values to determine whether a voxel belongs to a tumor or not. By choosing appropriate threshold values, regions of high intensity that indicate the presence of tumors can be isolated [22]. However, thresholding techniques alone may not be sufficient to handle the complexity and variability of brain tumors, as tumors can exhibit heterogeneous intensities and overlap with normal brain tissue. Thus, while thresholding can provide initial tumor regions, it is often combined with other segmentation or classification methods to improve accuracy and robustness in brain tumor detection.

**Region and contour-based techniques**

Region and contour-based techniques in brain tumor detection focus on identifying tumor regions based on their spatial characteristics and boundaries. These methods analyse the shape, texture, and spatial relationships of pixels or voxels to delineate tumor regions [9]. Region-based techniques involve grouping connected pixels with similar properties to form tumor regions, while contour-based techniques aim to trace the boundary of tumors. By considering the spatial information and connectivity of tumor regions, these techniques can better capture the shape and extent of tumors [10]. However, they may still face challenges in handling irregular tumor shapes, overlapping structures, and variations in tumor appearance. Therefore, combining region and contour-based methods with other advanced techniques, such as machine learning or deep learning approaches, can enhance the accuracy and reliability of brain tumor detection.



**Dipti Mathpal and Nikhil Gondaliya****Statistical based Techniques**

Statistical-based methods in brain tumor detection involve the use of statistical models and algorithms to analyse the characteristics and patterns of tumor regions in MRI images. These methods utilize statistical measures, such as mean, variance, and distribution properties, to distinguish tumor regions from normal brain tissue [9]. They often involve comparing the statistical properties of pixels or voxels within a region of interest to predefined thresholds or reference models. By leveraging statistical analysis, these methods can identify deviations from normal tissue behaviour, allowing for the detection of potential tumor regions. However, statistical-based approaches may face challenges in handling complex tumor appearances and variations, and they may require careful tuning of parameters and assumptions. Integrating statistical methods with other complementary techniques, such as machine learning or image processing algorithms, can enhance the accuracy and robustness of brain tumor detection.

**Machine Learning Technique**

Machine learning techniques in brain tumor detection utilize algorithms and models to automatically analyse MRI images and classify regions as tumor or non-tumor. These methods learn from labelled training data, extracting relevant features from the images and training models to make predictions [8]. Common machine learning techniques used in brain tumor detection include support vector machines (SVM), random forests, and neural networks [8]. These models can capture complex patterns and relationships within the data, enabling accurate identification and segmentation of tumor regions. Machine learning-based approaches offer the advantage of automation, objectivity, and scalability, allowing for efficient and consistent tumor detection. By leveraging large datasets and learning from examples, these techniques have the potential to enhance the accuracy and efficiency of brain tumor detection, aiding in early diagnosis and treatment planning.

**Deep Learning Technique**

Deep learning techniques in brain tumor detection utilize deep neural networks, such as convolutional neural networks (CNNs), to automatically analyse MRI images and identify tumor regions. These models learn hierarchical representations of the data, extracting complex features and patterns from the images [15]. By leveraging large amounts of labelled training data, deep learning models can learn to accurately classify pixels or voxels as tumor or non-tumor, as well as perform precise segmentation of tumor regions. Deep learning-based approaches have demonstrated exceptional performance in brain tumor detection, achieving high accuracy and robustness [19]. They have the ability to handle variations in tumor appearance, shape, and size, making them well-suited for the complexity of brain tumors. With their capacity to learn from data, deep learning techniques hold great potential for improving early detection, facilitating treatment planning, and enhancing patient outcomes in brain tumor detection.

**Hybrid Learning Technique**

Hybrid learning techniques in brain tumor detection combine the strengths of multiple machine learning approaches, such as traditional statistical methods and deep learning models, to improve the accuracy and reliability of tumor detection [20]. These methods leverage the complementary capabilities of different algorithms and models to enhance performance. For example, statistical methods may be used for initial tumor region identification based on intensity or texture analysis, while deep learning models can be employed for fine-grained segmentation and classification tasks. By integrating these techniques, hybrid learning approaches aim to overcome the limitations of individual methods and provide more robust and accurate tumor detection results. This hybridization allows for a comprehensive analysis of MRI images, leveraging the strengths of both statistical and deep learning approaches to achieve improved brain tumor detection outcomes.

**Conventional Method of Brain Tumor Segmentation**

Conventional methods of brain tumor segmentation refer to traditional approaches that have been used prior to the emergence of deep learning techniques. These methods often involve manual or semi-automatic processes performed by radiologists or medical experts. Here are some commonly employed conventional methods for brain tumor segmentation



**Dipti Mathpal and Nikhil Gondaliya****Manual Segmentation**

Radiologists visually inspect MRI images and manually outline tumor regions using image editing software [11]. This approach is time-consuming, subjective, and can vary among different experts, leading to inter-observer variability.

**Thresholding**

This technique involves setting intensity thresholds on MRI images to separate tumor regions from healthy tissue. Pixels with intensity values above a certain threshold are classified as tumor regions. However, thresholding alone may struggle with variations in tumor appearance and overlapping structures.

**Region Growing**

Region growing methods start with a seed point or region and iteratively expand the region by including neighbouring pixels or voxels that meet certain criteria [12]. These criteria can be based on intensity similarity, gradient information, or other image properties. Region growing can be sensitive to seed selection and may struggle with complex tumor shapes [13].

**Active Contour Models**

Active contour or "snake" models are deformable curves or surfaces that can be iteratively adjusted to fit the tumor boundaries. These models are influenced by image features such as intensity gradients or edges. They require initialization and parameter tuning but can handle irregular tumor shapes.

**Watershed Transformation**

The watershed transformation treats image intensity as a topographic surface and simulates flooding to segment objects. It identifies basins and watershed lines to delineate tumor regions. However, it can produce over-segmentation or under-segmentation in the presence of noise or intensity variations.

**Template-Based Segmentation**

This method involves utilizing pre-segmented templates or atlases of tumor images as references. The templates are registered and aligned with the patient's MRI images, and the tumor regions are transferred or propagated based on the registration [22]. It relies on the availability of a representative template dataset.

While conventional methods have been widely used, they often require extensive user intervention, are prone to subjectivity and variability, and may struggle with complex tumor characteristics. The emergence of deep learning techniques, particularly convolutional neural networks, has shown great promise in addressing these limitations and improving the accuracy and efficiency of brain tumor segmentation.

**Similarity Metric**

Validation is crucial for the computer-aided analysis of medical images, particularly for segmentation tasks. However, there is a lack of a definitive "ground truth" or "gold standard" for analysing in vivo acquired data. To address this challenge, various databases containing MR brain images with known ground truth annotations are freely accessible for experimental analysis. Evaluation metrics offer a solution to the validation problem by allowing the comparison of segmentation results with the ground truth. Similarity coefficients are commonly employed as metrics, and two examples of such coefficients are widely used in the field.

**Dice's Similarity Coefficient**

Dice's coefficient (DC) is used as a similarity measure between two sets.

$$DC = \frac{2|A \cap B|}{|A| + |B|}, \text{ where } 0 \leq DC \leq 1$$

Here, A is a set of ground truth voxels and B is a set of voxels labelled using segmentation method [25].





**Dipti Mathpal and Nikhil Gondaliya****Jac card Similarity Coefficient**

Jac card similarity coefficient is used for comparing similarity and diversity of a sample sets. It measures similarity between finite sample sets as follows.

$$J(A, B) = \frac{|A \cap B|}{|A \cup B|}, \text{ where } 0 \leq J(A, B) \leq 1$$

Here, A is a set representing annotated voxels of a ground truth and B is a set of labelled voxels generated by any method. Jaccard distance  $dJ(A, B)$  measures dissimilarity between sample sets.

$$dJ(A, B) = 1 - J(A, B)$$

It is complementary to the Jaccard coefficients [26].

**Open Source Tools for Brain Image Analysis****3-D Slicer**

3D Slicer is a software platform that facilitates the analysis of medical imaging data, including registration, segmentation, and visualization. It is an open-source software that can be utilized on various operating systems. One of its key advantages is its extensibility, allowing users to incorporate additional algorithms and applications through plug-ins. The features of 3D Slicer encompass support for multiple imaging modalities such as MRI, CT, ultrasound, nuclear medicine, and microscopy. Moreover, it offers visualization capabilities for a wide range of organs, spanning from head to toe.

**Visualization Toolkit**

The Visualization Toolkit (VTK) is a freely accessible, open-source software system designed for 3D image processing, computer graphics, and visualization. It is compatible with multiple operating systems and offers a diverse range of algorithms for working with scalars, vectors, tensors, textures, and volumetric methods. VTK provides extensive support for various types of data and enables users to perform advanced visualization and analysis tasks.

**Tumor Sim**

Tumor Sim is a simulation software that is compatible with multiple operating systems. It generates pathological ground truth data based on the existing healthy ground truth data for adults, such as the brain web data. To run the software, users need to provide an input directory containing information about healthy anatomy, anatomical probabilities, mesh, and diffusion tensor image. TumorSim utilizes this input to simulate pathological conditions and generate corresponding ground truth data for further analysis and evaluation.

**Robust Brain Extraction (ROBEX)**

Robex is a tool used for automatic skull stripping, which is a pre-processing step in brain image analysis that involves removing non-brain tissues from the head image. It is designed to achieve reliable skull stripping results across various datasets without the need for manual parameter adjustments. z With the advancement in computational capabilities and the availability of large annotated datasets, researchers have increasingly turned to deep learning techniques for segmentation tasks. The following section provides an overview of deep learning, including the utilization of convolutional neural networks, and explores its applications in brain tumor segmentation.

**Deep Learning**

An artificial neural network is considered as a simplified model of the human brain. In the early 1980s, researchers began utilizing neural networks for tasks such as credit card fraud detection, character recognition, and similar applications. However, interest in neural networks diminished due to limited computational power and small datasets. Nowadays, with the availability of powerful computing systems and larger datasets, applications like Google's instant auto complete suggestions, Facebook's photo tagging, and driverless cars have gained popularity. These applications demonstrate the increasing effectiveness of artificial intelligence (AI). Deep Learning, a subfield of



**Dipti Mathpal and Nikhil Gondaliya**

machine learning, is built upon a set of algorithms that form a robust framework for supervised learning. Geoffrey Hinton introduced deep learning as a response to the limitations of traditional machine learning algorithms. These limitations include difficulties in handling high-dimensional data (curse of dimensionality), failure to address statistical challenges without implicit assumptions (such as smoothness and local constancy), reliance on human domain knowledge for feature representation instead of leveraging available data, and the inability to generalize well in complex tasks like speech or object recognition. Deep learning aims to overcome these challenges by employing multiple layers and a large number of units within each layer to represent highly complex functions. These layers form a hierarchy that captures features from low to high levels, allowing the model to learn high-level abstractions from the data. Additionally, the layers incorporate nonlinear processing units and facilitate supervised learning on feature representations. By utilizing deep learning, researchers can effectively address the limitations of traditional machine learning algorithms and achieve more accurate and abstract representations of data.

**The benefits of deep neural networks can be summarized as follows:**

1. Deep learning offers a notable enhancement in performance compared to traditional segmentation methods.
2. It eliminates the need for manual feature engineering, which is typically a time-consuming aspect of machine learning.
3. Deep learning models possess an adaptive architecture that can easily adapt to new problem domains.

A convolutional neural network (CNN) is a type of deep network specifically designed for solving supervised learning tasks, such as image segmentation. On the other hand, a recurrent neural network (RNN) is another specialized form of deep network that excels in processing sequential data. While RNN is capable of working with sequential data of varying lengths, CNN is suitable for both fixed-length and variable-length data. As a result, CNN has gained popularity as a preferred method for addressing image segmentation challenges, which will be further explored in the upcoming subsection.

**Convolutional Neural Network**

A Convolutional Neural Network (CNN) is a type of deep learning model that is particularly effective in analyzing and processing visual data, such as images. It is inspired by the structure and functionality of the visual cortex in the human brain. CNNs are designed to automatically extract relevant features from input data through the use of convolutional layers. These layers apply filters or kernels to input data, performing local operations and capturing spatial patterns. The filters slide over the input data, performing convolutions and producing feature maps that highlight different aspects of the input. Typically, a CNN consists of multiple convolutional layers, interspersed with pooling layers that down sample the feature maps and reduce their dimensionality. This hierarchical structure allows the network to learn increasingly complex and abstract features as it progresses through the layers. The final layers of a CNN usually include fully connected layers and a soft max activation function for classification tasks or a pixel-wise prediction layer for segmentation tasks. One of the key advantages of CNNs is their ability to automatically learn and extract relevant features from raw input data, eliminating the need for manual feature engineering. This makes CNNs particularly effective in tasks such as image classification, object detection, and image segmentation. Additionally, CNNs can handle input data of different sizes and scales, making them versatile for a wide range of visual data analysis tasks. Due to their impressive performance and ability to capture spatial information, CNNs have become a cornerstone in various applications, including computer vision, medical imaging, autonomous vehicles, and natural language processing. Their success is attributed to their deep architecture, parameter sharing, and efficient learning algorithms, which enable them to handle large and complex datasets while achieving state-of-the-art results.

**Network Design Aspects of Deep Learning**

To enhance the performance of a designed network, it is crucial to employ effective algorithms and have a solid understanding of the underlying principles guiding these algorithms. The quality of segmentation results obtained from a network relies on several factors, including the availability of ample and diverse data, the capacity of the model to handle complex patterns, the use of regularized features to prevent overfitting, optimization techniques to



**Dipti Mathpal and Nikhil Gondaliya**

fine-tune the network parameters, and the proper debugging of the software implementation [42]. By addressing these aspects, one can improve the accuracy and reliability of the segmentation results produced by the network. The design of the network relies on the following factors [43]:

1. Choosing a suitable performance metric to evaluate the network's effectiveness.
2. Developing an end-to-end pipeline that encompasses all necessary steps for the task at hand.
3. Identifying performance bottlenecks that may lead to underfitting, overfitting, or the introduction of errors in the data or software.
4. It is recommended to make incremental modifications based on the system's observations.

This could involve gathering additional data, fine-tuning hyper parameters, or changing algorithms to address any identified issues. The choice of performance metric is influenced by various factors, including the output features of the neural network, the stochastic nature of the network, and the availability of data. Achieving zero error is extremely challenging, so it is more practical to aim for an acceptable error rate. Developing an optimal neural network may require a significant amount of data, which can be time-consuming and resource-intensive. Therefore, it is advisable to use datasets with ground truth for training and testing, as this helps overcome many of these constraints. In addition to accuracy and error rates, precision and recall are alternative metrics used to evaluate performance. Different measures are needed in certain situations where accuracy may not be an appropriate metric. For example, when detecting a rare disease in a patient, accuracy alone may not suffice. In such cases, precision and recall are utilized as performance metrics. Precision measures the fraction of correctly reported detections by the model, while recall measures the fraction of true events that were correctly detected. Once the performance metric is determined, a default baseline model is selected based on the type of available data. For instance, if the input is a fixed-size vector, a feed-forward neural network is a suitable choice.

Convolutional Neural Networks (CNNs) are well-suited for topological data such as images, while Recurrent Neural Networks (RNNs) are suitable for sequential data [45]. Additionally, optimization algorithms such as stochastic gradient descent (SGD), regularization techniques, and stopping criteria are set up along with the baseline model. The selection of proper hyper parameters for deep learning algorithms also plays a crucial role in improving the model's quality. There are two approaches to selecting hyper parameters: manual and automatic. Manual hyper parameter selection involves considering factors such as the model's representational capacity, its ability to minimize the cost function, and regularization. Hyper parameters that can be manually tuned include the number of hidden layers, the number of units in a hidden layer, the learning rate, tuning parameters, convolutional kernel width, dropout rate, etc [44]. Automatic hyper parameter selection can be done through grid search or random search. The model's performance is then evaluated at each point in the grid or at random locations to determine the best set of hyper parameters.

**CNN ARCHITECTURES FOR BRAIN TUMOR SEGMENTATION**

Several researchers have successfully utilized Convolutional Neural Networks (CNNs) for the segmentation of brain tumors. The input to the CNN consists of one of the four MRI modalities: T1, T1c, T2, and FLAIR. These modalities are provided to the CNN as either 2D or 3D patches for the segmentation process. In the case of single voxel label prediction, the output is generated for the central voxel within the 2D or 3D patch. For multi voxel prediction, the output includes predictions for multiple voxels. Typically, these methods are implemented and evaluated on the BRATS dataset [27], where the MRI images are registered with the T1c image slice by slice. Prior to applying the CNN, the images undergo basic pre-processing, which includes normalization and bias-field correction. Normalization addresses the issue of the lack of a standard image intensity scale in MRI, which can cause problems in image display and analysis. Bias field refers to a low-frequency signal that can corrupt MRI images, and its removal is necessary for improved segmentation results. Additionally, post processing techniques are employed to remove very small regions that may be misclassified as tumorous voxels. An example of bias-field correction in an MRI image is illustrated in Figure 5.



**Dipti Mathpal and Nikhil Gondaliya**

Mohammad et al. [28] proposed two different architectures for Convolutional Neural Networks (CNNs): the two-pathway architecture and the cascaded architecture. In the two-pathway architecture, the input is fed into two separate CNNs: The Local path CNN and the Global path CNN. The Local path CNN focuses on capturing the visual details surrounding a voxel, while the Global path CNN considers the larger context. The outputs of these two CNNs are then concatenated to generate the final output value. On the other hand, the cascaded architecture involves passing the output parameters of one CNN as input to a second CNN, known as the Two path CNN. Depending on the point of cascading, the CNN is referred to as either Input Cascade CNN or Local Cascade CNN. In the case of Input Cascade CNN, the output of the first CNN is concatenated with the input of the second CNN. In the Local Cascade CNN, the output of the first CNN is concatenated with the first hidden layer of the local path CNN, and then with MFCascade CNN, which is the concatenation of the output of the first CNN and the output of a penultimate layer.

The data used for brain tumor segmentation is imbalanced, with healthy brain tissues making up 98% of the voxels and the remaining 2% representing tumorous tissues. This imbalance poses a challenge during the training of Convolutional Neural Networks (CNNs) as the healthy labels can dominate and cause issues. To address this problem, a two-phase training approach is employed using 2D patches. In the first phase, the CNN is trained on a balanced dataset where each class label is equally represented. In the second phase, the unbalanced data is considered, and only the output layer of the CNN is retrained. Normalization is performed by removing 1% of the highest and lowest intensities, followed by subtracting the mean and dividing by the standard deviation. Additionally, the N4ITK bias-field correction [29] is applied to T1 and T1c images. L1 and L2 regularization terms are incorporated into the negative-log likelihood functions at the hidden layers using the dropout method. During post processing, a connected component-based method is applied to remove spurious blobs that may appear in the predictions, particularly near the bright corners of the brain close to the skull. In reference [30], the authors presented two distinct architectures for high-grade glioma (HGG) and low-grade glioma (LGG). The HGG architecture consisted of 11 layers, while the LGG architecture had a depth of 9 layers. Input data in the form of 2D patches underwent intensity normalization and bias-field correction before being fed into the networks. After generating the segmentation labels, small clusters of voxels were removed based on a predefined threshold.

In reference [31], the author proposed a CNN architecture that takes 2D patches as input. The preprocessing step involved intensity normalization with histogram matching. The network incorporated normalization and bilinear interpolation at a hidden layer, which included rectified linear unit (ReLU) activation and max pooling. Reference [32] introduced a two-pathway architecture that accepts 3D patches as input for the CNN. The input images were normalized to have zero mean and unit variance. Post processing steps included conditional random field (CRF) refinement to enhance the boundary between the tumor and the background. Additionally, morphological operations were applied to remove isolated false positives. In reference [33], the authors proposed a CNN that takes 3D input patches. Bias-field correction and normalization were performed on T1 and T1c images as part of the pre-processing stage. Post processing involved applying a closing operation to eliminate small dark spots and connect small bright cracks. Connected component removal was also employed to eliminate components smaller than a specified threshold size. Lastly, in reference [34], an 8-layer CNN architecture designed for 2D image patches was proposed. One of the CNN architectures [32] is shown in Fig. 6. The authors of this chapter implemented this architecture on NVIDIA Quadro M2000 GPU using sample dataset. Results of the experimentation are shown in Fig. 7. The training and validation accuracies approach 1, indicating a high level of accuracy in both sets. Similarly, the Dice similarity coefficient, which measures the overlap between the predicted and ground truth segmentations, is close to 1 during training, indicating a strong agreement. However, during validation, it slightly decreases to 0.85. Additionally, measures such as specificity and sensitivity exhibit values close to 1 for both the training and validation sets. These metrics collectively demonstrate the effectiveness and efficiency of the brain tumor segmentation, highlighting its successful performance.



**Dipti Mathpal and Nikhil Gondaliya****CNN Tools**

Theano [35]: Theano is a Python library designed for creating efficient mathematical expressions that involve multidimensional arrays. It offers several important features, including GPU support for faster computations and seamless integration with NumPy. It also ensures accurate results for logarithmic functions with very small input values and utilizes dynamic C code generation to enhance evaluation speed. Torch [36]: Torch is a scientific framework developed to facilitate machine learning algorithms on GPUs. It provides support for multidimensional arrays, along with functionalities for linear algebra, slicing, transposing, and other mathematical operations. Torch also offers an interface to the C language and incorporates models specifically designed for neural networks. Pylearn2 [37]: Pylearn2 is a machine learning library built on top of Theano. It utilizes mathematical expressions to develop Pylearn2 plug-ins and leverages Theano's optimization capabilities for enhanced performance. Mxnet [38]: Mxnet is a deep learning framework that offers a balanced approach to symbolic and imperative programming, maximizing efficiency and productivity. It boasts portability, lightweight design, and scalability across multiple GPUs. CNTK [40]: CNTK is a comprehensive deep learning toolkit developed by Microsoft Research. It offers the flexibility of being used as a library within Python or C++ or as a standalone tool. CNTK supports the Brain Script model description language for convenient model development and experimentation. Tensor Flow [41]: Tensor Flow is a freely available software library designed for performing numerical computations, particularly involving multidimensional arrays. It enables the creation of flexible architectures that can be seamlessly deployed on single or multiple CPUs or GPUs. Caffe [39]: Caffe is a deep learning framework known for its expressive architecture and extensible codebase. It operates efficiently with various data types and delivers high-speed processing capabilities.

**SUMMARY AND DISCUSSION**

This chapter presents a range of conventional approaches for brain tumor segmentation, each with its own limitations. These limitations include: (1) Small dataset sizes, which can introduce bias and limit generalizability. (2) Over fitting risks associated with random forest-based methods. (3) Challenges faced by symmetry-based methods when tumors exhibit symmetry along the mid sagittal plane, compounded by the difficulty of accurately identifying this plane. (4) Failures of atlas-based and probabilistic methods when tumors cause deformations in normal tissues, making accurate registration with atlas images challenging. Additionally, all these methods require hand-crafted feature sets for segmentation, heavily relying on expert knowledge. As per the study done, the K-means clustering method yielded poor results. This can be attributed to its reliance on basic features such as histograms for selecting tumorous voxels. In T2 images, the intensity of tumorous tissue may resemble that of other non-brain tissues in the skull and CSF, making the removal of non-tumorous voxels difficult. Enhancements to K-means clustering can be explored, such as incorporating additional features like symmetry, which can aid in correctly identifying CSF.

Furthermore, many conventional methods rely on small custom datasets, including widely available databases like BRATS. Consequently, while these methods may perform well on specific datasets, their generalizability is limited. For automatic brain tumor segmentation, artificial neural networks (ANN), support vector machines (SVM), and random decision forests (RDF) can be employed. As discussed in the previous section, convolutional neural networks (CNN) have shown exceptional results in brain tumor segmentation. CNNs have emerged as powerful tools for implementing deep learning due to their rich and resourceful architecture. Hence, it is crucial to examine the distinctions between artificial neural networks (ANN) and convolutional neural networks (CNN). However, there are several similarities between ANN and CNN, including the following:

1. Both ANN and CNN possess the capability to acquire knowledge through interactions with the environment.
2. They rely on supervised learning and require training data to solve problems effectively.
3. Both networks can self-organize based on the information processed during the learning phase.
4. Once trained, both ANN and CNN can deliver real-time performance when applied to testing or inference tasks.





**Dipti Mathpal and Nikhil Gondaliya**

It is important to note that the weights of the network alone do not provide a comprehensive understanding of the underlying functional relationship between the input and output.

**Challenges and Future Direction**

This chapter explores the topic of brain tumor segmentation, encompassing both conventional methods and convolutional neural networks (CNN). Manual analysis of medical images can be time-consuming, thus automated segmentation methods are valuable for reducing diagnosis time. The focus of the chapter is on MRI images, which are widely used in brain scans. It addresses the challenges and goals associated with brain tumor segmentation. Initially, the chapter delves into conventional segmentation methods such as thresholding, region growing, artificial neural networks (ANN), and support vector machines (SVM). These methods rely on various features extracted from the images and employ similarity metrics to quantify the segmentation results. The K-means clustering algorithm is applied to the BRATS dataset for experimental analysis, revealing unsatisfactory segmentation outcomes. While conventional supervised methods are established to a certain extent, they fail to consistently improve segmentation results. Additionally, these methods rely on human experts for feature extraction.

Deep learning, particularly through the use of CNN, offers a powerful framework for supervised learning. It significantly enhances segmentation results compared to conventional methods. The chapter focuses on the implementation of CNN for brain tumor segmentation and highlights various CNN architectures. An architecture proposed in [32] is implemented on a GPU to study tumor segmentation using the BRATS dataset. The results of this experimentation are highly encouraging, as the similarity coefficient for tumor segmentation is notably high. It is worth noting that some conventional methods may provide better segmentation results, but this can be attributed to the small dataset, which introduces bias. Furthermore, only one or two modality images are used as inputs in conventional methods, which can improve the results. In contrast, CNN utilizes all four MRI modality images with a larger dataset, enabling better generalization capabilities across various tumors. However, CNN requires specific hardware setups like GPUs for efficient training and testing, resulting in faster response times. Such hardware setups are not mandatory for conventional segmentation methods. Additionally, due to the larger dataset, feature generation is more time-consuming compared to conventional methods. Nevertheless, once the CNN model is trained, the test time is significantly reduced. Nowadays, with powerful hardware, the response time of deep learning methods is becoming comparable to conventional methods. One of the major challenges in this field is accurately locating and predicting the growth rate of a tumor, which aids in treatment planning and predicting patient survival time in cases where the tumor is incurable. However, such predictions require temporal images of a patient, which can be difficult to obtain.

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**Dipti Mathpal and Nikhil Gondaliya**

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**Dipti Mathpal and Nikhil Gondaliya**

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**Dipti Mathpal and Nikhil Gondaliya**

**Table 1: Summary of a few studies utilized Deep Learning, Auto Encoders and Hybrid Techniques techniques for brain tumor detection**

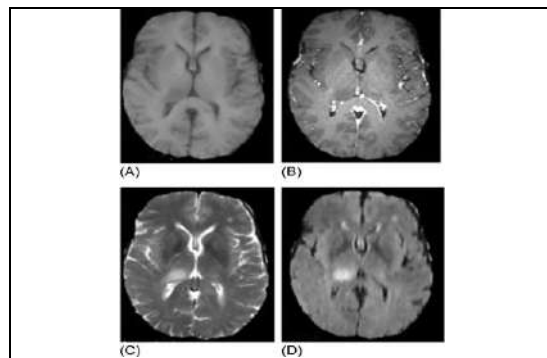
Technique	Modality	Tumor Type	Size of Dataset	Performance (%)	References
DCNN	T1-W, T2-W, FLAIR, CE-T1W	Low Grade Glioma, High Grade Glioma, Edema	30 images	Dice Similarity Coefficient: Whole Tumor: 80, Tumor Core: 67 Active Tumor: 85	[46]
CNN	T1-W, T2-W, FLAIR, CE-T1W	Astrocytomas, Anaplastic astrocytomas, Glioblastoma multiforme, Low grade gliomas, High Grade Glioma	65 images	Dice Similarity Coefficient: Whole Tumor: 88, Tumor Core: 83 Active Tumor: 77	[47]
ECNN	-	-	-	Accuracy: 92	[60]
CNN	CE-T1W, T2-W	Low Grade Glioma	159 images	Accuracy: 87.7	[52]
Supervoxel learning	T1-W, T2-W, FLAIR, CE-T1W, DTI	Low Grade Glioma, High Grade Glioma, Edema	30 images	Dice Similarity Coefficient: 89	[57]
Stacked denoising auto-encoders	T1-W	Brainstem cancer	9 patients	Dice Similarity Coefficient: 92	[50]
Variational auto-encoder-generative adversarial network	FLAIR	MS lesion	Training: 83 Testing: 49 images	Dice Similarity Coefficient: 60.50	[48]
Conditional variational auto-encoder	-	Glioblastoma multiforme	Training: 3000 Testing: 29550 images	Baseline: 84 U-net: 88	[58]
Convolutional autoencoder-based inter-slice interpolation	-	Glioma, Meningiomas, Pituitary tumors	3064 images	Low Grade Glioma, High Grade Glioma	[51]
Constrained adversarial auto-encoders	T2-W	Lesions	Training: 35 Testing: 42 images	Area under the curve: AAE with $\lambda=0.5$ is 0.906 $\lambda=1.0$ is 0.923	[59]
GA + SVM	T2-W	Glioblastoma multiforme, Low Grade Glioma	83 images	Accuracy: 94.44 - 98.14	[49]
K-means integrated with Fuzzy c-means	DS-II: T1-W, T2-W,	Low Grade Glioma, High Grade Glioma	DS-I: 22 DS-II: 152	Accuracy: DS-I: 90.5	[56]



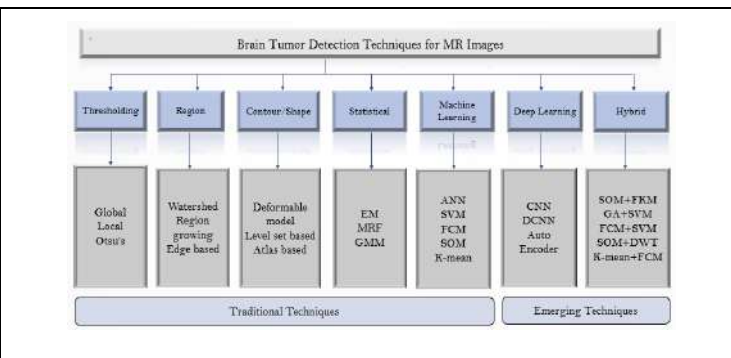


**Dipti Mathpal and Nikhil Gondaliya**

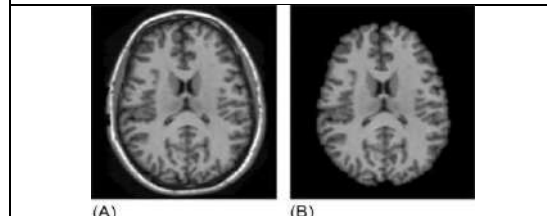
	PD DS-III: T1-W, T2-W, CE-T1W, FLAIR		DS-III: 81 images	DS-II: 100 DS-III: 100	
Ensemble Net + Incremental (2CNet, 3CNet)	T1-W, T2-W, FLAIR, CE-T1W	Glioblastoma multiforme	HGG: 210 LGG: 75 images	Dice similarity coefficient: 88	[53]
Multi-resolution wavelet morphological pyramid fuzzy c-means (WMMFCM)	T1-W, T2-W, FLAIR, CE-T1W	Multiple sclerosis, Low Grade Glioma, High Grade Glioma	DS-I: 81 DS-II: 152	Accuracy: DS-I: 95.853 DS-II: 97.05	[54]
Deep neural network discrete wavelet transform (DNN-DWT)	T2-W		66 images	Glioblastoma multiforme, Metastatic bronchogenic carcinoma	[55]



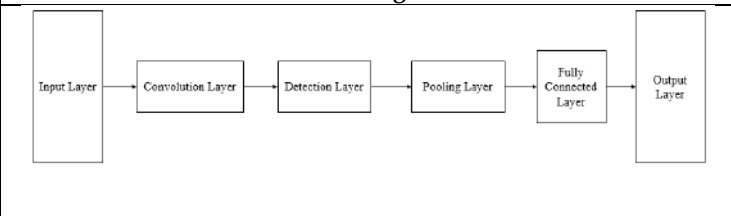
**Fig 1: Different Modalities of MRI Images (A) T1 (B) T1c (C) T2 (D) FLAIR**



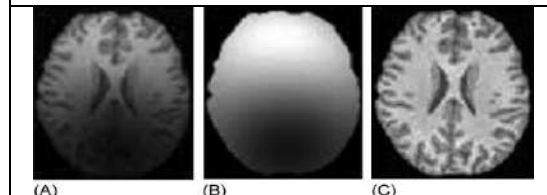
**Fig 2: Classification of Brain Tumor Detection Techniques for MR Images**



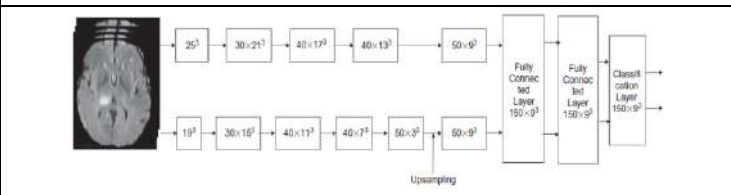
**Fig 3: MR Image (A) With a skull (B) Without a skull**



**Fig 4: CNN Architecture**



**Fig 5: (A) Original MRI image, (B) bias field, and (C) bias-field corrected image.**

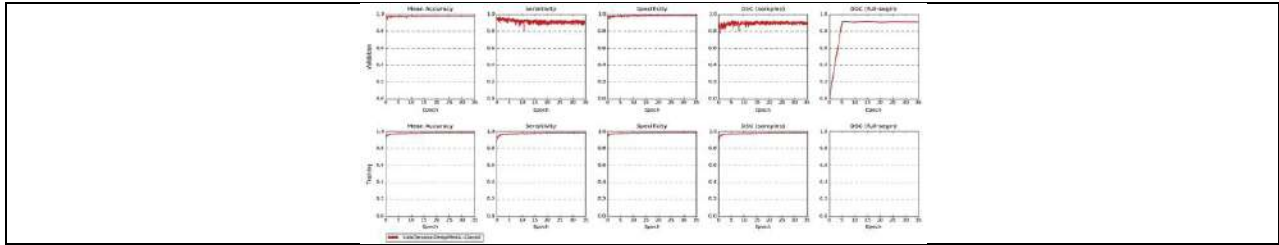


**Fig 6: Deep Medic CNN architecture [32].**





**Dipti Mathpal and Nikhil Gondaliya**



**Fig. 7: Evaluation metrics for architecture in Ref. [32].**





# Fake News Detection using Machine Learning and Natural Language Processing

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## ABSTRACT

In an era marked by the rapid dissemination of information through social media, the proliferation of fake news poses a critical challenge to the integrity of online information. This research addresses this issue by employing a multi-pronged approach, utilizing logistic regression, decision tree, gradient boosting, LSTM, and BERT models, to discern the veracity of news content. Leveraging a comprehensive dataset sourced from Kaggle, encompassing diverse news articles prevalent on different news papers websites, we train and evaluate these models for their efficacy in distinguishing between genuine and fabricated information. Through NLP, it extracts various linguistic features, including textual patterns, sentiment analysis to build a comprehensive understanding of the content. This research not only contributes to advancing the field of fake news detection but also underscores the necessity for a multifaceted approach in combating misinformation on popular online platforms.

**Keywords:** Fake news detection · natural language processing · *machine learning* · BERT

## INTRODUCTION

In an era characterized by the rapid dissemination of information through digital platforms, the proliferation of fake news has emerged as a critical societal concern. Fake news, often defined as intentionally false or misleading information presented as genuine news, has the potential to misinform, deceive, and manipulate public opinion. Its impact extends across various domains, including politics, health, finance, and beyond. As the volume of online content continues to surge, distinguishing between reliable information and deceptive narratives has become an increasingly challenging endeavor. The phenomenon of fake news is not merely confined to the realm of social media or fringe websites; it has penetrated mainstream news cycles, amplifying its potential to influence public





**Maitri Patel et al.,**

discourse. Its prevalence has raised pressing questions about the ethics of information dissemination, the role of technology platforms, and the responsibilities of both content creators and consumers. This review paper seeks to comprehensively examine the landscape of fake news, encompassing its origins, dissemination mechanisms, psychological and societal impact, as well as the diverse array of methods and technologies developed to combat its spread. By synthesizing and critically analyzing the existing body of literature, this paper aims to provide a comprehensive overview of the multidimensional challenges posed by fake news, while also highlighting the innovative approaches that have been employed in its detection, mitigation, and prevention.

## RELATED WORK

The research in fake news detection has seen intense activity in recent years, with a primary focus on analyzing the dissemination of hoaxes through social media channels. Researchers have explored the integration of convolutional neural networks and linguistically-infused neural networks, leveraging techniques like Long-Short-Term-Memory (LSTM) and incorporating pre-trained vectors. The complexity of the models is not the sole solution; instead, the right choice of parameters and data proves essential. Despite the progress, the challenges persist due to the diverse variables associated with news statements, including sarcasm, abbreviation, metaphors, etc. One study proposed a method involving recurrent neural networks for stance detection of fake news. This approach captures temporal patterns of user activity, extracts source characteristics, and integrates them to form a classification model. It's worth noting that even simpler network models have demonstrated superior performance, highlighting the importance of parameter selection and data quality. Addressing the fake news problem requires aggressive efforts, given its alarming growth rate. The availability of reliable and extensive datasets is crucial for further progress in this area. In summary, the research landscape in fake news detection is diverse and evolving, encompassing various methodologies from classical machine learning to deep neural network approaches. There is still significant room for development, especially in tackling the intricate nature of news statements.

## DATA

The dataset used in this research paper is sourced from Kaggle and is titled "Fake and Real News Dataset". It is curated by Clément Bisailon and contains a collection of news articles, categorized into two distinct groups: genuine ("real") news articles and fabricated ("fake") news articles.

**Composition** The dataset is structured with two main components:

**Real News** This category comprises news articles from reputable and established news sources, recognized for their credibility and journalistic integrity.

**Fake News** This category encompasses news articles that have been intentionally created to mislead or deceive readers, often originating from less reputable or unverified sources.

**Size** The dataset includes a substantial number of articles, providing a diverse and comprehensive corpus for analysis. The specific number of articles in each category can be found in the dataset description on Kaggle.

**Attributes** Each news article in the dataset is typically represented by several key attributes, including but not limited to:

**Title** The headline or title of the news article.

**Text** The body of the news article containing the main content.

**Subject** The general category or topic to which the news article pertains (e.g., politics, world news, etc.).

## DATA PREPROCESSING TECHNIQUES

Involves cleaning, transforming, and organizing the raw data to make it suitable for training and evaluating the machine learning algorithms. The main tasks involved in data preprocessing for fake news detection include:

### Text Cleaning

Text cleaning involves removing any extraneous characters, symbols, or elements from the text that do not contribute to the meaning. This may include HTML tags, special characters, or any other noise in the data.

**Example** Removing HTML tags like <p> or &amp;



**Maitri Patel et al.,****Lowercasing**

Lowercasing entails converting all the text to lowercase. This is important as it standardizes the text and ensures that words are treated consistently regardless of their capitalization.

**Example** Converting "Hello World" to "hello world".

**Tokenization**

Tokenization involves splitting the text into smaller units, usually words or phrases (tokens). These tokens serve as the building blocks for further analysis.

**Example** Splitting the sentence "Natural Language Processing is amazing!" into tokens: ["Natural", "Language", "Processing", "is", "amazing", "!"].

**Stop-word Removal**

Stop words are common words (e.g., "the", "and", "is") that occur frequently in a language and do not carry significant meaning. Removing them helps reduce noise and focus on more meaningful content.

**Example** Removing words like "the", "is", and "and" from a sentence.

**Lemmatization / Stemming**

Both lemmatization and stemming are techniques used to reduce words to their base or root form. This helps in reducing the dimensionality of the data and capturing the core meaning of a word.

**Example**

**Stemming** Reducing words like "running", "ran", and "runs" to their common root "run".

**Lemmatization** Reducing words like "better", "best", and "good" to their base form "good".

**FEATURE EXTRACTION**

Involves converting raw text data into a set of numerical features that machine learning algorithms can process. Effective feature extraction is essential for capturing the relevant information from the text and representing it in a way that facilitates the detection of fake news.

**Word Embedding**

Word embedding is a technique that represents words as vectors in a continuous vector space. Each word is mapped to a high-dimensional vector where semantically similar words are located closer to each other in the space. This captures semantic relationships between words and is widely used in tasks like sentiment analysis, language translation, and more.

**Example:** In a word embedding space, words like "king" and "queen" might be closer to each other because of their semantic similarity.

**TF-IDF Vectorization**

TF-IDF (Term Frequency-Inverse Document Frequency) is a statistical measure used to evaluate the importance of a word within a collection of documents. It calculates a weight for each word based on how frequently it occurs in a document relative to its frequency in the entire corpus. This helps in identifying words that are distinctive to a specific document.

**Example:** In a collection of articles about cats, the term "cat" would have a high TF-IDF score because it's likely to appear frequently in each document.

**Count Vectorization**

Count vectorization, also known as Bag-of-Words (BoW), is a simple technique that converts text data into numerical vectors. It creates a vocabulary of unique words in the corpus and counts the frequency of each word in a given document. Each document is then represented as a vector with the count of each word from the vocabulary.





**Example** Consider the sentences "I love cats" and "I love dogs". In count vectorization, the vectors for these sentences might be [1, 1, 0, 0] and [1, 0, 1, 0] respectively, where the positions correspond to the words ["I", "love", "cats", "dogs"]. These feature extraction techniques are fundamental in converting textual data into a format that machine learning models can understand. They capture different aspects of the text, whether it's semantic relationships (word embedding), importance within a document (TF-IDF), or basic word frequency (count vectorization). The choice of technique often depends on the specific task and the nature of the text data being analyzed.

## MODEL DESCRIPTION

### LSTM

This architecture is based on LSTM cells which are a type of recurrent neurons that have proved to give very interesting results in problems related to sequence modeling as they have the capability to "remember" information from the past. The LSTM units are composed of several gates in charge of maintaining a hidden cell state which allows them to mitigate the vanishing gradient problem and, therefore, gives them the ability to remember more distant information in the past than vanilla recurrent units. This feature is important in the context of NLP since the words from the past often influence the current ones. More exactly, the architecture uses bidirectional LSTM layers, in which the sequence (ie. the text) is fed forwards and backwards. This decision is based on the intuition that in language, future words modify the meaning of the ones in the present. For example, polysemous words such as bank, mouse or book show that its context is needed in order to model their meaning. Later in the network, these representations are merged and classified in one of the two possible categories (true or fake).

### BERT

In recent years, a huge number of improvements have been made in the field of NLP thanks to deep learning. Most of the recent ones are based on a special type of architecture known as "transformer".

### Transformers

Its main goal is, given an input sequence, to transform it into another. The architecture uses "attention mechanisms", which are responsible of determining the most relevant parts of the input sequence. This way, better language representations are created because longer relationships in the sequence can be captured, usually further longer than with LSTM neurons despite of being more computationally efficient as the operations applied to the input are simpler. A transformer is based on the idea of having two pieces: an encoder and a decoder. The encoder creates a representation of a given input in a different dimensional space and then, the decoder takes that representation and generates other sequence. This strategy is called "encoder-decoder" and is widely used in tasks like text summarization or machine translation. A diagram of the transformer architecture is shown in the figure 2, where the left part corresponds to the encoder block and the right one to the decoder. Each transformer block uses a "self-attention" system which is in charge of choosing the most relevant parts of the input sequence. This system works by operating three matrices: Q, K and V (Query, Key and Value, respectively), which represent an abstraction to calculate the attention matrix, Z (equation 1). These three matrices are learnt through in the training phase of the network. After obtaining those matrices the Z matrix can be calculated as shown in equation 1, where  $d_k$  is the chosen dimension of each key vector (i.e the number of columns in K). In the original work, this value corresponds to  $d_k = 64$ .

$$Z = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}V\right) \quad [2]$$

Also, in the figure 2, several "Multi-Head Attention" blocks can be seen. These simply repeat the attention operation explained above  $n$  times, obtaining  $n$  attention matrices, which are concatenated and multiplied by other matrix, WO, in order to obtain an output that is fed to the normalization block ("Add & Norm", in the figure). Besides the Multi-Headed system, the researchers also proposed the use of skip-connections, in such a way an identity signal could be transmitted to deeper layers, improving the learning process.



**BERT Based**

BERT is a language model created by researchers at Google which is based on transformers. Roughly, it is composed of several stacked transformer encoder blocks. The strategy to follow with BERT falls under transfer learning. BERT is provided already pretrained on a large text corpora (books, Wikipedia, etc.) with the aim that the final user performs a fine-tuning phase to adapt the model to his specific problem. Google provides several pretrained models. In their work they present variants of the architecture: "BASE" and "LARGE" which differ in their size since the first one uses 12 blocks and the second 24 blocks. Due to computational power constraints, in the current work the "BASE" version has been used. This is also the approach followed in the original publication. The adaptation included in this work consists on adding an extra layer to the model provided by Google. This layer is a fully connected layer with sigmoid as activation function plus a softmax function on top to allow the interpretation of the result as a probability. For simplicity in the implementation and the possible future in which the model is required to classify articles in a broader set of categories, the number of neurons in this last layer can be changed as a function of the number of classes in the classification problem. For this binary classification problem (true/false) the number of output neurons is two. BERT input data format is different from the ones used for the other two architectures since it is based only on text strings. The word tokenization and separation processes are already included in the input data function for this model. The word tokenization follows a strategy called WordPiece. This considers the words as combinations of some more basic tokens joined together. For example, doing would be formed by joining do and ing. By separating the tokens like that, the available lexicon is largely increased, minimizing the potential number of OOV errors (Out Of Vocabulary). As BERT admits only one input vector, the title and the article body were concatenated before feeding in to the model.

**Supervised Machine learning algorithms: Decision tree, Random Forest, Gradient Boosting, Logistic Regression**  
**Decision Tree**

A Decision Tree is a flowchart-like structure where each internal node represents a feature (or attribute), each branch represents a decision rule, and each leaf node represents an outcome. It's a popular algorithm for classification tasks. The tree is constructed by recursively partitioning the data based on the values of features, aiming to minimize impurity or maximize information gain at each step

**Strengths**

1. Easy to interpret and visualize.
2. Can handle both numerical and categorical data.
3. Requires relatively little data preprocessing. Weaknesses:
4. Tends to overfit with complex trees, which may lead to poor generalization.
5. Sensitive to small changes in the data.
6. Limited ability to capture complex relationships.

**Random Forest**

Random Forest is an ensemble learning method that combines multiple decision trees to improve predictive performance and reduce overfitting. It builds multiple decision trees using bootstrapped samples of the data and random subsets of features for each tree. The final prediction is determined by aggregating the outputs of all individual trees.

**Strengths**

1. Reduces overfitting and improves generalization.
2. Handles large datasets with high dimensionality well.
3. Provides feature importance rankings. Weaknesses:
4. May be computationally expensive, especially with large number of trees.
5. Can be challenging to interpret compared to a single decision tree.

**Gradient Boosting**

Gradient Boosting is an ensemble learning technique that builds a series of weak learners (usually decision trees) sequentially, with each one correcting the errors of the previous one. It minimizes a loss function, typically using



**Maitri Patel et al.,**

gradient descent, to iteratively improve predictions. Common implementations include XGBoost, LightGBM, and AdaBoost.

**Strengths**

1. Often provides state-of-the-art performance on a wide range of problems.
2. Handles mixed data types and missing values naturally.
3. Robust to outliers and noisy data.

**Weaknesses**

1. Can be sensitive to hyperparameters and require tuning.
2. May be prone to overfitting, particularly with deep trees.

**Logistic Regression**

Despite its name, Logistic Regression is a classification algorithm used for binary and multi-class classification problems. It models the probability of a sample belonging to a particular class using the logistic function. It estimates coefficients for each feature to make predictions.

**Strengths**

1. Simple and computationally efficient.
2. Provides probabilities for classification.
3. Easy to interpret and explain. Weaknesses:
4. Assumes a linear relationship between features and the log-odds of the response variable.
5. May not perform well with highly non-linear relationships.

**COMPARISON USING ACCURACY****PROBLEMS**

1. While using LSTM we get low accuracy and over fitting problem
2. In other supervised learning model we face problem related to features

So, we use BERT model for our system because it gives good accuracy and work fine

**GUI****RESULT**

Using BERT

**CONCLUSION**

In conclusion, the pervasive influence of fake news in today's information landscape demands a concerted and multidisciplinary response. This review has delved into the multifaceted nature of fake news, exploring its origins, dissemination mechanisms, and far-reaching societal implications. The prevalence of deceptive narratives, often masquerading as legitimate news, poses a significant challenge to the integrity of information consumption and public discourse. As discussed, a wide array of approaches has been developed to combat the spread of fake news, ranging from traditional fact-checking to cutting-edge machine learning algorithms. These efforts underscore the urgency with which stakeholders across academia, industry, and government are addressing this pressing issue. While significant strides have been made, it is evident that the battle against fake news is an ongoing one, requiring continuous adaptation and innovation. The development of robust datasets, the refinement of detection techniques, and the cultivation of media literacy are integral components of a comprehensive strategy. Moreover, collaboration between technology platforms, media organizations, and researchers is crucial in fortifying the defenses against misinformation. Ethical considerations, such as preserving free speech while curbing the spread of false information, must remain at the forefront of these efforts. In conclusion, the fight against fake news is a collective endeavor that demands the concerted efforts of researchers, policymakers, and the wider public. By fostering a culture of critical thinking, leveraging advanced technologies, and upholding the principles of journalistic integrity, we can work towards a more informed and resilient society.





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Table 1: Accuracy Comparison

Sr. No.	Classifiers	Accuracy
1	LSTM	55%
2	BERT	80%
3	Logistic regression	88%
4	Decision tree	78%
5	Gradient boosting	77%
6	Random forest	80%

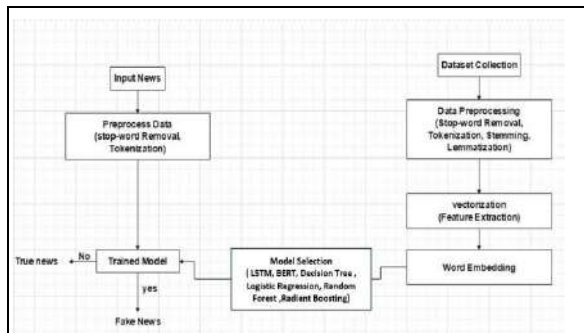


Figure 1:Flow of the System

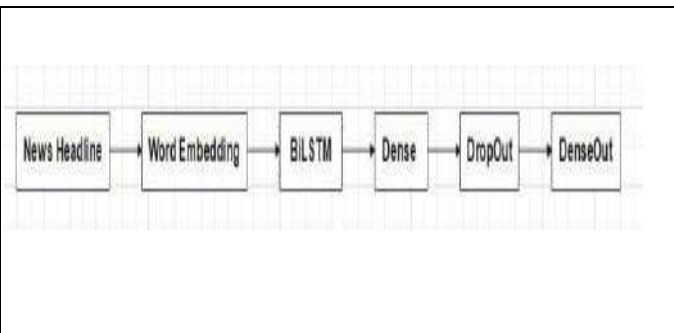


Figure 2:LSTM Architecture

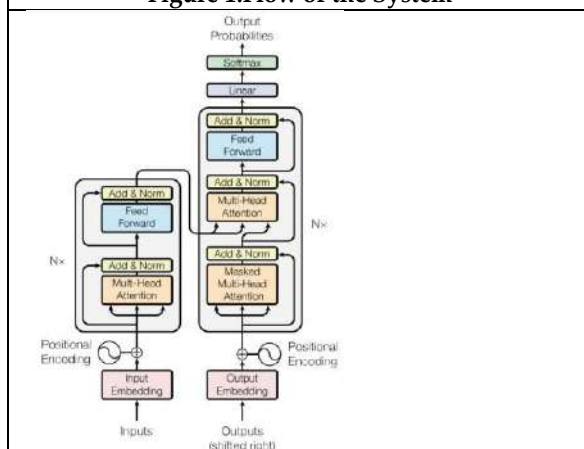


Figure 3: Transformer block diagram

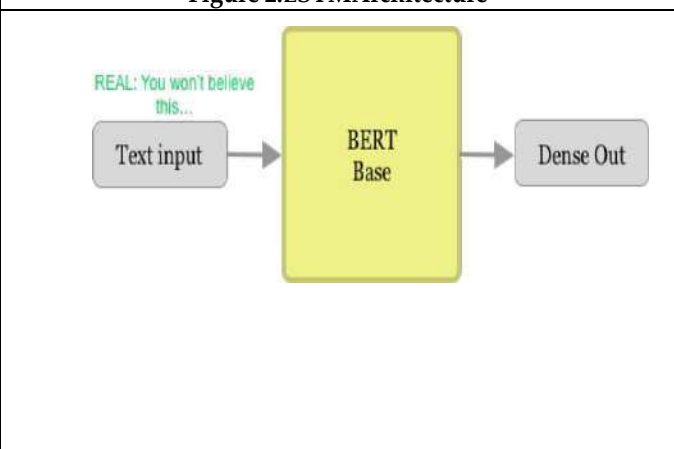


Figure 4: BERT based architecture diagram







Maitri Patel et al.,



Figure 5: GUI



Figure 6 : Real News

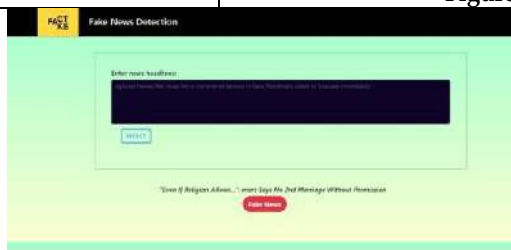


Figure 7 : Fake News





## Facial Emotion Recognition using Deep Learning

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### ABSTRACT

Facial emotion recognition (FER) is a crucial topic in the fields of computer vision, artificial intelligence, robotics, and automation, owing to its significant potential in the professional and industrial domain. Although FER can be conducted using multiple sensors and methods, this paper focuses on using facial images and gathering visual data of expressions. We know that while comprehending a person's emotions during interaction, facial expressions come to the most usage and it is like looking into someone's brain via their expressions. In this paper, it is going to use the deep-learning approach using Convolutional Neural Networks, to evaluate a person's emotion by acquiring their spatial facial features in real time. The framework that going to use is the latest method in use. Here exploit GPU computation and capture the pixel data through video streaming of our webcam. Next exploit Keras and Tensorflow to train our model.

**Keywords:** CNN, FER, Sequential model. Keras, Tensorflow, GPU, overfitting, HAAR Cascade

## INTRODUCTION

In the 21<sup>st</sup> century era, when science and technology have made great leaps, we cannot find a problem to which a solution cannot be found. The field of medicine, telecommunication, manufacturing, retail, transportation, consumer products, science of electronics and computing tends to find a solution to the toughest problems prevailing. With the advent of robotics and automation, the interaction of humans with machines has also increased, and it has gotten simpler to have a human connection with the technology. In this kind of phase, we see the urgency of various humane-prone aspects such as face recognition, speech recognition, human-figure recognition, gesture recognition, etc. Applications are multifarious; Human figure recognition helps in security and surveillance to prevent crimes, face recognition helps in various photographic and image manipulation and speech recognition also helps in various automation issues. Now we have leaped one step forward into the emotional aspect of technology, e.g. robotics. So capturing human emotions from various sources can help improve multiple aspects of technology such as diagnosis, consumer satisfaction, digital marketing, driver safety, etc., and hence emotion recognition has multiple applications.



**A B Bambhaniya et al.,**

Here, bring a method to facial emotion recognition, FER, using Convolutional Neural Networks, which is a deep learning method to gauge the machine's learning capabilities. Patient response, student concentration during learning, and Human-Robot Interaction (HCI) face challenges in recognizing facial expressions due to laceration, interpersonal disparity, and aging. Comprehensive analysis of facial expression recognition systems is lacking, highlighting pros and cons. The paper aims to use 3 layered Convolutional Neural Networks with the help of Python and OpenCV to implement software that can detect emotions from the faces. The prime emotions are happy, sad, surprised, angry, fearful, neutral, and disgust. Facial emotion recognition opens a whole new plethora of applications in itself. We will take input of the face from the regular webcam of our P.C. and output the emotions.

## LITERATURE SURVEY

Vasavi Gajarla and Aditi Gupta used various classification methods, including SVM and pre-trained models, to detect and analyze emotions in Flickr data [1]. Nithya Roopa attempts to transfer learning. Transfer learning uses knowledge obtained from one problem to solve another problem. They took the weights from the larger dataset, Kaggle here and implemented them on smaller ones, KDEF here. Using the Kaggle and Karolinska Directed Emotional Faces datasets, Inception Net is used for emotion identification, while the Fast Fourier Transform is employed for spectrogram charting. The final accuracy of this expression recognition model using the Inception Net v3 Model is 35 % (~). The challenge they faced was an image classification [2]. In the paper 'Facial Expression Recognition', Yingli Tian et al. used AFEA systems. They have studied various discrepancies that could arise during image classification. Some problems are multiple dimensions like level of description, individual differences in subjects, transition among expressions, intensity, deliberate vs spontaneous expressions, and multi-modal expression analysis. They have utilized head-pose estimation for when the head is out of a plane. The 3D tracking, and image-based methods are deployed [3]. Robert Jenke et al. conducted a study on feature extraction methods for emotion recognition via EEG, comparing their performance using machine learning techniques.

They found that multivariate methods performed slightly better than univariate methods, offering advantages over traditional spectral power bands [4]. Ayong-Hwan Lee in his research paper "Detection and Recognition of Facial Emotion using Bezier Curves", suggests an approach in which, the study uses Bzier curves to extract facial features and uses color segmentation based on fuzzy classification for face detection, addressing color ambiguity. The results of experiments demonstrate that the technique can clearly classify skin regions and the non-skin region. For deciding if the skin region is the face or not, the largest connectivity analysis has been used. The system recognizes facial expression types, changes, and intensity, and is implemented by issuing facial expression commands to a manipulator robot for human interaction. Researchers are developing automatic expression classifiers to classify faces into emotions like happiness, sadness, and anger, and recognize individual muscle movements. The Facial Action Coding System (FACS) is the best psychological framework for describing facial movements, using Action Units (AU) to classify human facial movements. Other techniques used are Bayesian Networks, Neutral Networks, and Multilevel Hidden Markov Model. Out of them, some stay back on the recognition rate and timing. Usually, two or more techniques are used. The success usually depends on the preprocessing because of the initial illumination and various factors.

### Proposed system

In this system, real-time emotion detection will be done. The video will be livestreamed through the webcam. With each frame, the image of the face will be extracted using HAAR cascading and template matching will be done, via which the code will decide the emotion of the image. The images will be first converted into grayscale images and the image of the face will be extracted by cropping away the background. In the system, we use the machine learning approach and train our dataset of the images downloaded from Kaggle's 'Challenges in Representation Learning: Facial Expression Recognition Challenge' [9]. This dataset contains 48\*48 greyscale images which are already labeled, and are centered. Hence the dataset is clean. The images are categorized into six types: angry, disgusted, fearful, happy, sad, surprised, and neutral. Train.csv has 3 columns which are 'emotion' (datatype: int64), 'pixels' (datatype:



**A B Bambhaniya et al.,**

object), and 'usage' (datatype: object) Emotion column is numbered from 0 to 6 and ascribes the emotion to the picture. The pixel column has a string that contains space-separated pixel values for each image in the row-major form. The usage column contains the labels for images. It is divided into 'training' and 'testing'. The test.csv file contains only the pixel column, which is to be used for training purposes. The training set has 28,709 images. The dependencies are pandas, NumPy, OpenCV, TensorFlow, and Keras. We normalize the dataset and train it through the convolutional layers of CNN. Here developed CNN with 3 layers. The whole method is divided into three steps. Step 1 deals with image acquisition using OpenCV frame by frame. Step 2 deals with face recognition using HAAR Cascade and Step 3 deals with predicting the emotion.

## METHODS

### Step 1: Image acquisition

Facial recognition systems use digital scanning, electro-optical cameras, or video to acquire images. The recognition rate is low when images have different poses, expressions, and illuminations, and decreases with a pose angle larger than 30 degrees [1].

### Step 2: Face recognition

Viola and Jones' algorithm uses Haar-like features, generating over 180000 features for a 24x24 pixel window, even for small images. The Haarcascade\_frontalface.xml file is used to detect faces. A rectangular box is put in after cropping the region of interest and then labeled as whatever emotion is predicted using an array. The image acquired by the web camera is converted into pixels 48 \* 48 to be compatible with the trained images [2].

### HAAR Cascade

A machine learning approach for face detection uses a cascade function trained from positive and negative images. The algorithm extracts features from these images, using Haar features. The computation for each feature calculation is time-consuming, but the introduction of integral images simplifies the process. This makes it faster to calculate the sum of pixels under white and black rectangles. The image shows two feature that are irrelevant, such as the region of the eyes being darker than the nose and cheeks. To select the best features from 160000+, Adaboost and Cascade Classifiers are used. Adaboost groups features into different stages of classifiers, applying one-by-one. If a window fails the first stage, it is discarded, and the window that passes all stages is considered a face region.

### Step 3: Training and Emotion detection

Using a sequential model, we add 3 convolutional layers Conv2D with an activation function relu for the non-linearity. Kernel size is specified to (3,3). And then Max Pooling layer with pool size (2,2), and strides (2,2), are given. Drop out of probability 0.5 is introduced to prevent overfitting. In the third convolutional layer block, a flatten layer is introduced. In the end, a fully connected Dense layer with activation. Relu and dropout 0.2 is introduced. The softmax function is utilized to convert a network's non-normalized output into a probability distribution over predicted output classes. Loss is calculated using Categorical Cross entropy. And 'Adam' optimizer is used. Then the model is trained and the weights are saved for further usage. First of all the dataset is split into two parts one for training and another for testing. Then the images are normalized by subtracting the mean from them and dividing by their standard deviation. Then they are passed through layers and finally plotted. Loss and accuracy are plotted on the graph using matplotlib library. The parameters observed are as follows:

### Convolutional Neural Networks

A Convolutional Neural Network (CNN) is a Deep Learning algorithm that can differentiate between different aspects of an input image using learnable weights and biases. It requires less pre-processing than other classification algorithms and can learn filters with enough training. The architecture of a ConvNet is inspired by the connectivity pattern of neurons in the human brain and the organization of the Visual Cortex. Individual neurons respond to stimuli in a restricted region of the visual field, overlapping to cover the entire visual area.





A B Bambhaniya et al.,

## RESULTS

The result was that after training for up to 70 epochs, we got less than 70% accuracy. The model fumbles between surprise and fear. It doesn't detect disgust at all. Mostly the wrongly detected emotion is neutral which is in all of the cases, except happy. The label fluctuates, which means it isn't stable on one string value.

## FUTURE SCOPE

Talking about the development in Facial emotion recognition, the scope is unbound. While, the development of the proposed method has a number of possibilities too! Inclusion of tough testing, variety of data set to feed, using of app to collect dataset from crowdsourcing, are some. Accuracy has scope for improvement too. Correct Recognition Rate has the scope for improvement with higher computation and more training. The paper stands as a precursor to many Government and enterprise applications and has expandable utilities. The automatic facial expression recognition system has numerous applications, including understanding human behavior, detecting mental disorders, and creating synthetic human expressions. As an application for blinds, with a speak-back, for them to know the emotions of the person they are interacting with. In security systems during personal investigations and lie detection, in the health sector, it can be useful for doctors to observe symptoms, and the assistive robot nurses or even apps and in photography, to click the image only when the person laughs, or doesn't blink his eye are some wide applications of this area.

## CONCLUSION

Here developed a Convolutional Neural Network for recognizing emotions from live video frames. The face was detected by the HAAR Cascade Classifier. Here evaluated their performances using post-processing techniques and found that accuracy doesn't increase more than 60-70% even despite the increasing epoch size. This shows that our model might be overfitting. Although the results are good under normal conditions with illumination and pose defects setting the inadequacies.

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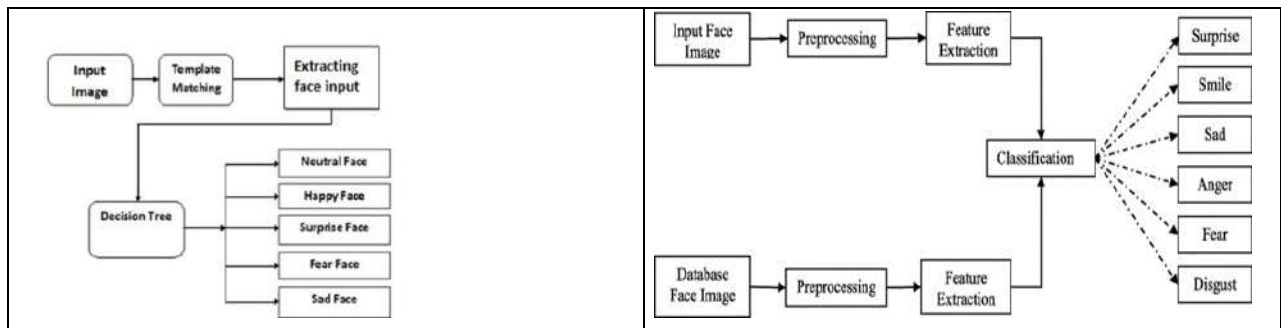


Fig. 1. Proposed system

Fig. 2. block diagram of the algorithm (FER)

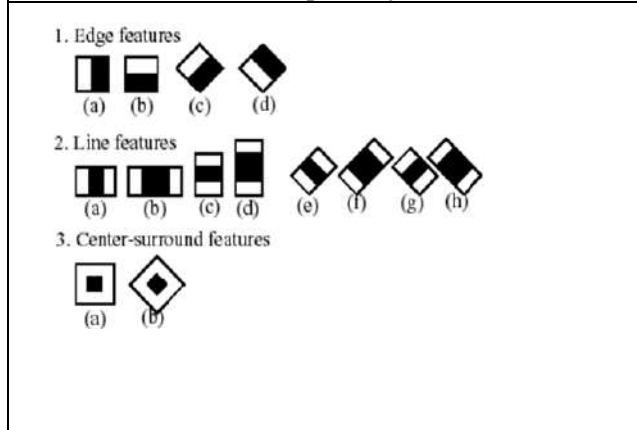


Fig. 3. HAAR feature extraction

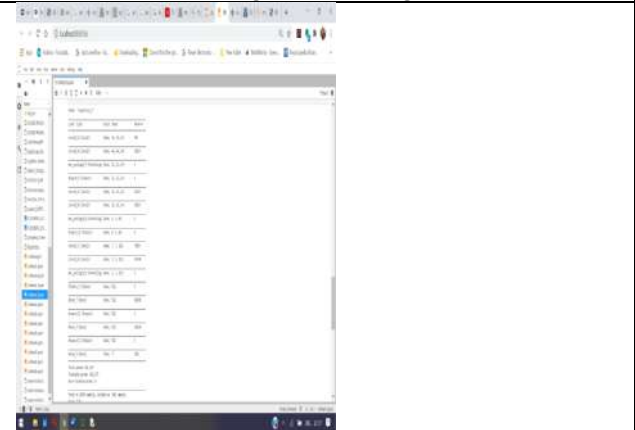


Fig. 4. Recorded parameters

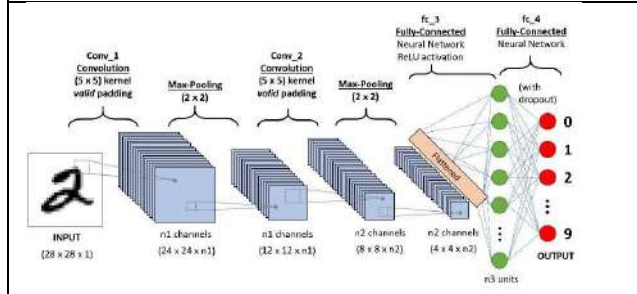


Fig. 5. CNN architecture

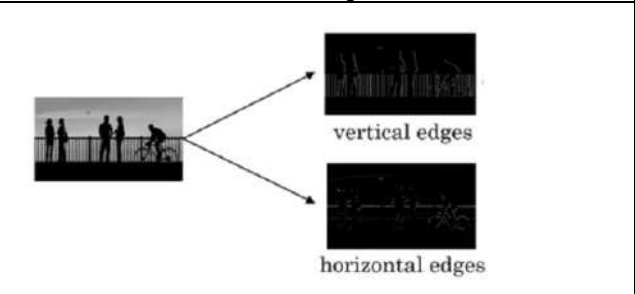


Fig. 6. Edge detection example using CNN







## RESEARCH ARTICLE

## ***Pseudomonas stutzeri* NC1: A Potent Halotolerant Diesel Oil Degradator and Versatile Biosurfactant Producer Isolated from Dwarka Coast, Gujarat, India**

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### **ABSTRACT**

In present study, eight native bacterial strains were isolated from Dwarka Coastal region, Gujarat. Among all, halotolerant isolate NC1 screened as potential surfactant producer. When provided with diesel oil as the sole carbon source, NC1 generated around 2.015 g L<sup>-1</sup> of biosurfactant and also emulsifying diesel oil effectively (up to 50%). Characterization identified the biosurfactant as a lipopeptide. NC1 demonstrated strong diesel oil degradation, breaking down 85% of the hydrocarbon, and genetic analysis confirmed its identity as *Pseudomonas stutzeri*. These findings suggest isolate NC1 as a potential candidate for remediating diesel oil in petroleum-contaminated environments.

**Keywords:** Surface active molecule, Diesel oil, Biodegradation, lipopeptide, *Pseudomonas stutzeri*

## **INTRODUCTION**

The rise of industrialization has led to a growing environmental concern known as petroleum hydrocarbon contamination (PHC), typically arising from underground storage tank leaks, mismanaged landfills, improper storage, or accidental spills [1]. Major oil spills, like the 2019 Brazil and 2010 Deepwater Horizon disasters, wreak havoc on the environment and marine life. The Brazilian spill, affecting 3,000 kilometers of coastline, imperiled 27 species and had severe economic consequences. In the Gulf of Mexico, the Deepwater Horizon event claimed lives, killed tens of thousands of animals, and severely damaged marine ecosystems. These tragic incidents highlight the crucial need for effective prevention and remediation strategies to mitigate oil spill devastation [2]. Consequently,



**Boski Thakkar et al.,**

biological remediation methods are gaining prominence over physical and chemical approaches due to their greater efficiency, cost-effectiveness, and environmentally friendly nature [3,4]. Biological detoxification techniques harness living organisms, particularly microbes, to convert petroleum hydrocarbons into environmentally harmless substances such as CO<sub>2</sub>, CH<sub>4</sub>, H<sub>2</sub>O, and biomass [5,6]. However, the bioavailability of petroleum hydrophobic organics (PHOS) to these microorganisms can be limited. To overcome this, the addition of surfactants above their CMC (critical micelle concentration) values reduces surface tension, enhances PHOS solubility and bioavailability, thus promoting biodegradation [7]. Aneurinifactin, a novel lipopeptide biosurfactant, was identified in a remediation study as derived from the marine bacteria *Aneurinibacillus aneurinilyticus* strain SBP-11. This strain demonstrated stable emulsification throughout a broad pH range of 2–9 and temperatures as high as 80 °C [8]. In order to treat the diesel-contaminated water and soil, Whang et al., 2008 used biosurfactants, rhamnolipid, and surfactin [9]. Numerous studies have reported biosurfactant production from diverse marine organisms. Given the vast and largely unexplored marine biosphere, the search for highly efficient biosurfactant-producing marine microorganisms could accelerate the adoption of eco-friendly surface-active agents, potentially reducing the need for chemical surfactants [10,11]. To cope with the crude oil, another study team used the biosurfactant-producing bacterium *Pseudozyma* sp. NII 08165 [12].

Surfactants, whether synthetic or biological, belong to amphiphilic chemicals and play a crucial role in reducing surface and interfacial tensions by bringing together immiscible fluids [11]. These surfactants enhance the surface area of hydrophobic pollutants in soil or water, thereby increasing aqueous solubility and accelerating microbial decomposition [13]. Unlike chemical surfactants, which can lead to secondary pollution due to residue and instability under varying conditions, biosurfactants are preferred for their biodegradability, environmental friendliness, increased foaming capacity, lower toxicity, and greater stability in adverse environments. Biosurfactants like lichenysins, rhamnolipids, and surfactin, produced by *Bacillus* and *Pseudomonas* species, have demonstrated their effectiveness in oil contamination remediation. Notably, marine microorganisms are particularly promising biosurfactant producers due to their remarkable metabolic and physiological adaptability, which is often rare in terrestrial microorganisms. These marine microbes can thrive in harsh marine conditions characterized by high salt concentrations, extreme pressure, and temperature fluctuations. Furthermore, their ability to thrive in oligotrophic environments means they require minimal nutrients for growth. This unique combination of traits positions them as valuable assets for addressing oil contamination issues in marine ecosystems [14]. Looking at the above facts, the present study was aimed to determine the biosurfactant production potential of halotolerant isolate and diesel oil- degrading efficiency have been studied.

## MATERIAL AND METHODS

Water samples were obtained from coastal region of Dwarka situated at coordinates 22.23°N, 68.96°E. These samples were collected and preserved in sterile wide-necked bottles at 4°C for subsequent analysis. Additionally, used diesel oil, a key component of the study, was sourced from a garage and vehicle service center in Anand, Gujarat.

### Enrichment and Isolation

Sample was serially diluted up to 10<sup>-4</sup> and was spread on Zobell marine agar (ZMA) with different salt concentration (Himedia, India). A 10% v/v bacterial culture of 1.0 OD (600 nm) was inoculated [11] 100 mL of sterilized Bushnell Haas Medium (BHM) containing 1% diesel oil (v/v) in a 250 mL conical flask. The culture was then incubated for 7 days at 35°C and 180 rpm. The BHM formula was prepared following literature guidelines and diesel oil was filtered through a 0.22 mm Millipore membrane before sterilization at 121°C for 20 minutes [9]. Strains displaying diverse morphologies and biosurfactant production were selected and preserved in 60% glycerol at -80°C for future use.



**BoskiThakkar et al.,****Primary screening of biosurfactant**

Drop collapse method (DCM). Cell-free supernatant (CFS) was obtained by centrifuging the culture broth at 8000 rpm for 20 minutes and then filtering it through a 0.22 mm Millipore membrane filter. flat-shaped droplets on the surface indicate favorable results, while spherical droplets signify adverse effects [15]. Oil-spreading method (OSM). The oil-spreading test, involved placing 10 $\mu$ l of diesel oil over 20 mL of distilled water in a 150 mm diameter Petri dish to form a thin oil layer. After gently adding 10 $\mu$ l of CFS at the center of the oil surface, the diameter of the oil-spreading area was measured [15].

**Secondary screening of biosurfactant**

Cetyl trimethyl ammonium bromide (CTAB) agar test. In the CTAB agar test, a 50 mm diameter section of the CTAB-methylene agar plate was utilized, and 20 mL of CFS was applied to the pre-cut circles. The successful production of biosurfactants was confirmed by the appearance of dark blue halo zones on the plate following incubation at 35°C [15]. Hemolytic assay (HA). The culture broth was streaked on a blood agar plate and incubated for 36 hours at 35°C. The presence of yellow translucent zones surrounding colonies indicated hemolysis, while unchanged plate color signified the absence of hemolysis [15]. Emulsification activity. To assess the emulsifying activity of the biosurfactant, the emulsification index (E24) was employed. In a 15 mL test tube, two milliliters of CFS and diesel oil were vigorously vortexed for five minutes. The test tube was then left undisturbed at room temperature for 24 hours. According to Zhang et al., 2018, the E24 can be calculated as follows:[16]  
$$E24 = (\text{Height of the emulsification layer} / \text{total height of mixture}) \times 100$$

**Molecular identification**

At the National Centre for Microbial Resource (NCMR), National Centre for Cell Science, Pune, genomic DNA extraction from the isolates was performed using the standard phenol/chloroform extraction method. Subsequently, the 16S rRNA gene was amplified via PCR using universal primers 16F27 and 16R1492. The 16S rRNA gene PCR product was purified through PEG NaCl precipitation and sequenced using an ABI® 3730XL automated DNA sequencer from Applied Biosystems, Inc. Sequences were analyzed using the NCBI website's Blast function to identify the most closely related strains. Multiple sequence alignment was performed with CLUSTAL W, and a phylogenetic tree was constructed using the neighbor-joining method, facilitated by MEGA version 11.0 software [17].

**Biosurfactant production kinetics**

The biosurfactant production kinetics of isolate NC1 were determined by monitoring biosurfactant yield, emulsification, and surface activity at various time intervals. Initially, the strain NC1, stored at ultra-low temperature, was activated and cultured in ZMB medium with 5% of NaCl for 12 hours at 37°C and 180 rpm. The bacterial culture was centrifuged, and the supernatant discarded. A suspension was prepared using sterile deionized water, and this suspension was inoculated into a Bushnell Hass (BH) medium with 1% (w/v) diesel oil as the carbon source. The BH medium composition and pH were specified. Biosurfactant production yield was measured, and crude biosurfactant was dried and weighed gravimetrically. Oil-spreading diameter and E24 were also determined as described [18,19].

**Extraction of the biosurfactant**

Isolate NC1 produced biosurfactant during a 96-hour aerobic fermentation at 35°C and 180 rpm. The culture supernatant (CFS) was acidified by reducing the pH to 2 with 6 N HCl and left at 4°C overnight. Subsequently, the CFS was centrifuged at 8000 rpm for 20 minutes to obtain the precipitate, known as crude biosurfactant. The biosurfactant was collected, dissolved in distilled water, and then dried using lyophilization [20].

**Characterization of the biosurfactant**

Ninhydrin Test: In this test, 5 drops of ninhydrin solution were added to 5 ml of the culture's supernatant. The mixture was boiled for 5 minutes, and color changes were observed [18].



**Boski Thakkar et al.,**

**Heavy Metal Precipitation Test:** A heavy metal protein precipitation method was used to detect proteins in biosurfactants. The appearance of a blue precipitate upon adding 10% copper sulfate to the supernatant confirmed the presence of biosurfactant [18]. **Anthrone Test:** The anthrone test was used to detect the carbohydrate moiety in the biosurfactant by mixing equal amounts of anthrone reagent and the supernatant and observing any color change [18]. **Saponification Test:** In the saponification test, 5 ml of the supernatant was mixed with 2 ml of 2% NaOH, and the mixture was vigorously mixed and observed for any changes [18].

#### **Thin-layer chromatography (TLC) and FTIR**

The study utilized TLC (thin-layer chromatography) on silica gel plates to confirm the composition of the biosurfactant. The biosurfactant, dissolved in methanol, was applied to the plate, and the TLC solvent was composed of chloroform, methanol, and acetic acid (65:15:2, v/v/v). Detection methods included exposure to a 1% ninhydrin reagent, a reagent containing acetic acid, sulfuric acid, and p-anisaldehyde, as well as exposure to iodine vapor. Additionally, Fourier transform infrared spectroscopy (FTIR) was employed to analyze the biosurfactant using the KBr pellet method, pressing a pellet with 2 mg of lyophilized biosurfactant and 100 mg of KBr. Spectra were examined in the 400 to 4000  $\text{cm}^{-1}$  wavelength range using a Bruker Vertex 70 FTIR spectrophotometer and the OPUS 3.1 program [19].

#### **Diesel oil degradation**

The biodegradation rate of diesel oil was assessed using a gravimetric method. Activated bacteria (OD600 1.0) were introduced into 100 mL of BH medium containing 1% (v/v) diesel oil in a 250 mL flask. Degradation took place over two weeks at 37°C and 180 rpm. Double extraction ensured complete recovery of diesel oil, which was then treated with sodium sulfate, evaporated to dryness, and the degradation percentage calculated as described [19].

#### **Gas Chromatography (GC) analysis**

Isolate NC1 was employed to decompose diesel oil as control and extracted residual diesel oil. The analysis was conducted using a SCION-456 gas chromatography system, which is employed for the degradation study. Nitrogen served as the carrier gas, and specific parameters were set for the injector and detector. An automatic sampler was employed for this analysis. one microliter of diesel oil that had been dissolved in n-hexane. The column temperature programme was maintained at 35 °C GC Analysis [19]. **Statistical Analysis:** Results were presented as mean standard error (SE), with three repetitions of experiments, and statistical analysis was performed by SICART (Vallabh Vidyanagar, Anand). Graphs were created using Origin 8.0.

## **RESULTS AND DISCUSSIONS**

#### **Isolation and screening of biosurfactant-producing bacteria**

**Identification of Biosurfactant Producers:** Eight bacterial strains (NC1 to NC8) were isolated from Dwarka coastal region, and primary and secondary tests, such as the drop collapse technique (DCM) and oil-spreading were employed to identify biosurfactant producers. Four strains (NC1, NC4, NC5, and NC7) exhibited positive results in the preliminary biosurfactant production screening (Table 1). In which isolate NC1 found as gram negative rod shaped halotolerant bacteria which was survived the salt up to 0% to 5% (fig 1A) , showed oil displacement  $7.3 \pm 0.2\text{cm}$  of the diameter (Fig.1B) and drop collapse test was also found positive (Table 1) From above results isolate NC1 selected for further screening , the CTAB agar test was used to detect anionic surfactants where NC1 strains tested negative, while the hemolytic assay demonstrated a noticeable hemolytic effect in cultured NC1 strains. (Table 2). On a blood agar plate, broth was distributed (Fig. 1D). The hemolysis of biosurfactants may be caused by the formation of mixed micelles between biosurfactant molecules and the phospholipid bilayers on cell membranes, which causes the rupture of cell membranes [21]. Therefore, the surface activity of biosurfactants is higher when the hemolysis is stronger. The performance of biosurfactants depends on their emulsifying activity. E24 is a parameter used to gauge emulsifying power (Table 2). Among the four strains, NC1 has the highest E24, which can reach up to 50% (Fig 1C) The



**Boski Thakkar et al.,**

strain NC1 is the most effective isolated strain producing biosurfactants, according above results and selected for further study.

**Molecular identification**

Analysis using the Genbank BLAST program showed that isolate NC1 displayed 100% similarity to *Pseudomonas stutzeri*, and identified as *Pseudomonas stutzeri* NC1. A phylogenetic tree was constructed using MEGA version 11.0 based on the 16S rRNA sequence of strain NC1 (Fig 2). The 16S rDNA sequence of isolate NC1 was deposited to Genbank database and accession number OR608228 was received.

**Biosurfactant production kinetics**

In an aerobic environment using a BH and diesel oil mixture, *Pseudomonas stutzeri* NC1 exhibited rapid growth, an expanding oil-spreading layer, and the production of 2.015 g/L of biosurfactants (Fig. 3). Biosurfactants can be produced using various water-soluble and hydrophobic carbon sources as substrates [22,23]. The bacterial strains *B. subtilis* and *P. aeruginosa* may break down the aromatic and aliphatic hydrocarbons found in crude oil by producing biosurfactants when they use crude oil as their only carbon source [24].

**Preliminary identification of biosurfactant chemical structure**

Biochemical tests were performed to analyze the biosurfactant's composition. The Ninhydrin test indicated the presence of proteins and amino acids by forming the Ruhemann's purple complex. A heavy metal precipitation test produced a blue precipitate, confirming the presence of proteins. The Anthrone test revealed no blue-green color, indicating the absence of carbohydrates in the biosurfactant. Furthermore, a saponification test confirmed the presence of lipid compounds as NaOH saponified the lipids (Table 3). The TLC analysis indicated the presence of peptide moieties upon spraying with ninhydrin in the biosurfactant, with an R<sub>f</sub> value of 0.78, and iodine vapor confirmed the presence of lipids, suggesting a lipopeptide composition. FTIR analysis identified an N-H aliphatic primary amine peak at 3444.34 cm<sup>-1</sup> in the freeze-dried biosurfactant from *Pseudomonas stutzeri* NC1. The FTIR spectra of the biosurfactant produced by *Pseudomonas stutzeri* NC1 suggests the presence of various components, including aliphatic methyl, C=O with NH<sub>2</sub> stretching, sulphate salts, and a nitro aromatic molecule. These findings indicate that the biosurfactant is likely composed of lipids and peptides. The biosurfactant formed by the *Pseudomonas stutzeri* NC1 that degrades diesel oil is observed to contain likely lipid and peptide components based on the results of FTIR spectra [25,26] (Fig. 4)

**Diesel oil degradation**

The biodegradation rates of four biosurfactant-producing diesel oil hydrocarbons (NC1, NC4, NC5, NC7) were determined using a gravimetric method. After 14 days of incubation, NC1 degraded 92.85% of 1% diesel oil, while NC4 degraded 71.42%, NC5 degraded 53.57%, and NC7 degraded 82.14%. In contrast, the diesel oil in the blank flask showed no degradation. When bacteria were introduced, little oil remained, but numerous white granular objects were present in the culture broth or adhering to the bottle wall. The NC1 isolate was identified as the most effective at degrading diesel oil, and GC analysis was conducted for a more detailed examination. In a study involving the NC1 isolate for diesel degradation, gravimetric analysis revealed its high efficiency. Further analysis using GC (Gas Chromatography) showed that nearly all hydrocarbons in diesel were degraded with NC1 strain being the most effective. Some new peaks also appeared in GC chromatogram of degraded sample. The chromatogram of diesel without bacterial inoculation contained 75 peaks, seven of which had an area greater than 2.57%. In contrast, when diesel oil was inoculated with the NC1 strain, the chromatogram displayed 41 peaks, 17 of which had an area greater than 2.57% (fig 5). Interestingly, there was a difference in the peak areas between the non-inoculated diesel oil sample and the one inoculated with NC1, indicating the degradation to probably structurally simpler compounds due to the formation of some new compounds. Several reports have been published supporting *Bacillus* and *Pseudomonas* genera as effective biosurfactant producers and applicable in environmental field [24,27–30]. The present study also indicates the potential of isolate *Pseudomonas stutzeri* NC1 in various applications like bioremediation and biodegradation.







Boski Thakkar et al.,

## CONCLUSION

The present study highlights *Pseudomonas stutzeri* NC1 as a highly proficient biosurfactant producer and diesel oil degrader among the isolates collected from the coastal region of Dwarka. The strain NC1 demonstrated outstanding capabilities, emulsifying 50% of diesel oil with the concomitant production of a lipopeptide biosurfactant. Characterization studies confirmed the nature of the biosurfactant. Furthermore, the exceptional hydrocarbon degradation abilities of NC1 were evident, achieving a remarkable 92.85% breakdown of diesel oil. These findings suggest *Pseudomonas stutzeri* NC1 as a promising candidate for the remediation of petroleum-contaminated sites. Its proficiency in both biosurfactant production and hydrocarbon degradation suggests its potential application in environmental cleanup efforts, particularly in addressing issues related to diesel oil contamination. The identified lipopeptide biosurfactant adds an extra dimension to its remediation capabilities, making it a valuable asset in the pursuit of sustainable and effective solutions for petroleum-contaminated environments. Further research and application studies could enhance our understanding and utilization of *Pseudomonas stutzeri* NC1 for environmental remediation purposes.

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**Table 1: Primary screening of biosurfactant producer by Drop collapse method (DCM) and Oil spreading method (OSM)**

	NC1	NC4	NC5	NC7
DCM	++	++	+	++
OSM	+++	++	+	++

Key: DCM: (-) completely spherical; (+) flat; (++) moderately flat; (+++) completely flat. OSM: (-) no displacement; (+) 3 cm < the diameter < 5 cm; (++) 5 cm < the diameter < 7 cm; (+++) 7 cm < the diameter < 9 cm; (++++) 9 cm < the diameter

**Table:2 Secondary screening of biosurfactant production**

Characterization of biosurfactant	NC1
E24	50%
CTAB	-
Hemolysis test	+

**Table:3 Primary characterization of biosurfactant from isolate NC1**

Characterization of biosurfactant by biochemical Test	NC1
PROTEIN	
1)Ninhydrin	+
2)Heavy metal	+
LIPID	+
CARBOHYDRATE	-



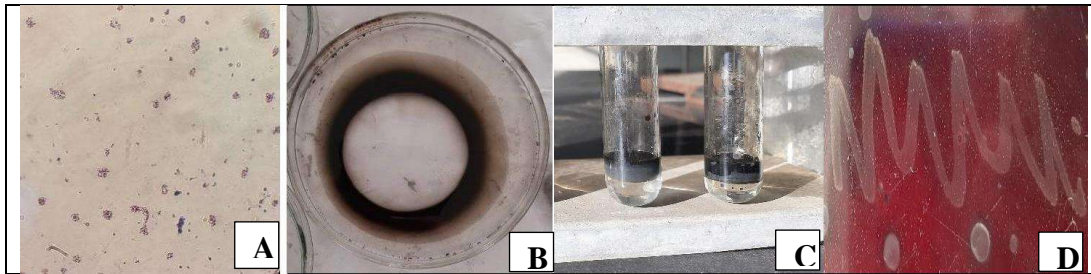


Fig:1A) Gram's staining B) Oil displacement C) Emulsification index D) Growth of NC1 on Blood agar plate

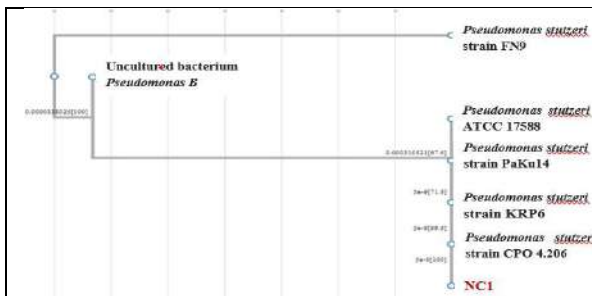


Fig2: Phylogenetic analysis of isolate NC1

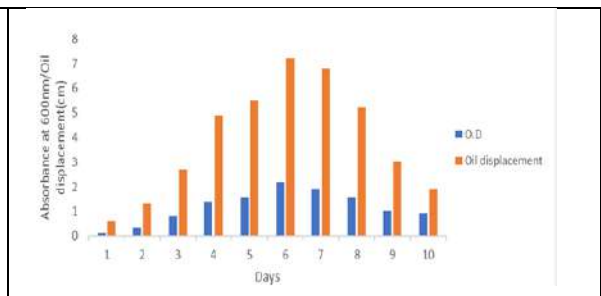


Fig3 : Growth of NC1 with Its Oil displacement

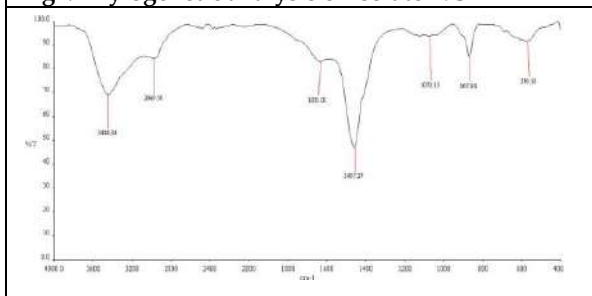


Fig. 4 Fourier transform infrared spectrum (FTIR) of lyophilized biosurfactant produced by *Pseudomonas stutzeri* NC1 cultivated in 1% (v/v)

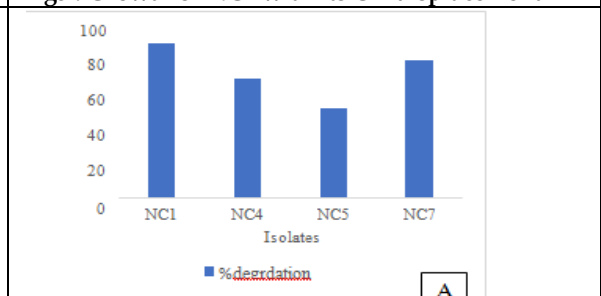


Fig 5:Chromatogram of GC Analysis A) Diesel oil degradation (%) by gravimetric analysis.

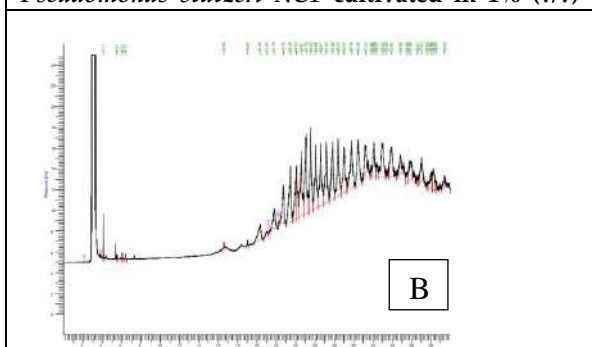


Fig 5. b) Uninoculated diesel oil as control

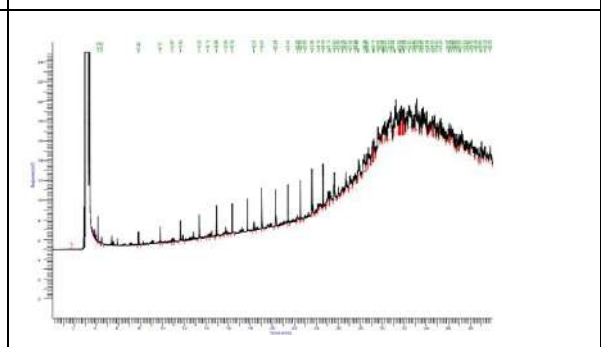


Fig 5. c) Diesel oil Inoculated with NCI isolate





## SLHD: Safety of Little Heart Device to Protect Crime Against Girl Child

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### ABSTRACT

Crime against the children specifically girl child in India is terrifically getting common in recent times. In reality, every day, at least five news articles describe the horrifying specifics of separate atrocities. The child safety in India is horribly low especially where kids are treated like god or goddess. The crime rate against the child is very high and getting increased day by day in India. The crimes like domestic abuse, harassment, child labor and other similar issues are prevalent throughout the nation. So as, being an IT professional we proposed a solution through which a child can use it to come out from the critical situation. In the proposed system when anything unwanted happens against the child, the device senses the body temperature, rate of heartbeat, voice frequency and also recognizes the word like "MUMMY", "HELP", and triggers some notifying actions. The actions include SMS, multiple calling, sharing live location, tracking, capture images and notifying the guardian. Guardian can then listen the voice of a child through mic by switching on the mic through android application.

**Keywords:** Cloud Computing, IoT, GPS, GSM, SMS, Firebase, camera, mic, LED, WIFI, Battery

## INTRODUCTION

It is impossible to find a day that and Indian media does not have any news on crime on child or youngster. Actually, there are at least five news stories that go into detail about the individual crimes' gory aspects. As per the reports on National Crime Records Bureau (NCRB) and the National Cybercrime Reporting Portal (NCRP) receives 13244 reports of child pornography, rape and gang rape between January 1, 2020 to September 18, 2020. From March 1 to August 31, 2020, the National Commission for the Protection of Child Rights (NCPCR) collected information about 420 cases of child sexual abuse via online portals, helplines, and other media. From March 1 to September 15, the Child line India Foundation (CIF) received 3,941 calls about child sexual abuse incidents [1]. Despite having so many laws for kids, crimes like thieves, assault or molestation doesn't stop and child safety become major concern. Even though invention of the advanced technologies, kidnapping, eve teasing, and sexual harassment still happen in



**Kamini Solanki et al.,**

a country like India. Recent self-defense devices have been invented which senses the emergency and sends the live location and other alert messages to the registered mobile number. It also triggers siren by sensing body temperature, heartbeat rate, voice frequency, etc.

Main objectives of the device are

1. Child Safety against domestic violence
2. Trace live location using GPS
3. Decrease the ratio of child harassment
4. Emergency call and Alert message service

**WORDS FROM LITERATURE**

To protect children and woman, significant work has been done by many researchers with through implementation of recent and advanced technology. The researchers have narrated their work by describing the specifications of the device to protect child and woman [3]. Many of them ensure safety using Raspberry Pi and camera module from a Raspberry Pi. The ultimate focus of such devices is to help the victim by informing the police or similar agency to track the victim and provide immediate help. Live location can be traced of the victim so as can get immediate help. Such implementation can catch the attacker as well with precise tracking method. Almost all such devices are activated through manual input and dependent of response of the recipient. Smart phone enabled applications can be activated by pressing emergency switch of the device to take appropriate action [4]. Here two important concepts are used to reach for a particular solution. In the first, self- defense is used, while in the second, the victim's location is sent to particular access numbers.

This project has used a Raspberry Pi, an Arduino Uno, a GPS module, a GSM module, and other related hardware [4]. With the Raspberry Pi, real-time photo and video streaming has been accomplished. The victim can also use Arduino Uno or ESP32 as a self-defense tool by connecting it to GPS, GSM, and an electric teaser. This device broadcasts information about the victim's location to the fixation number, just like the last one did. [5]. A victim can use this app to communicate her location and a warning note to the police station, a family member, friends, and admin. Users who are within 100 meters of the incident victim will then receive notification from the administrator. One user can follow another user using application's unique code. The benefits of this approach are limited to two things, despite the fact that it can help secure a woman's movement. First of all, it would be more beneficial if this system were fully automated and did not depend on the administrator to find users who were within 100 meters of the victim. A three- way security system for women's safety is designed in the study [6]. Additionally, they developed a voice- activated smartphone application. In addition to record a video, sound the alarm, and send an alert message to a pre-selected number, this gadget also allows you to communicate with an emergency number.

**SAFETY SYSTEM ANALYSIS**

The proposed system shown in Figure 1 uses distinct techniques like SOS message, GSM and GPS networks for the prompt communication when the child is under the treat. The system also captures the images and audio of that time and uploads them to database

**SYSTEM IMPLEMENTATION**

IoT has revolutionized in the field of automation and specifically safety measures can be improved by advent use of IoT. Various types of sensors are used along with GPS module, GSM module, SOS are used to develop the proposed system. The peripherals used in the proposed device is as follows:

1. Registration: Register guardian number in the mobile application in case of emergency to notify them as shown in Figure 3.
2. Voice Sensing: the chip can be embedding in wrist watch which senses the body temperature, heartbeat rate or feared voice like "Help – Help". The steps are shown in Figure 4.





**Kamini Solanki et al.,**

3. SMS: Sends SMS to registered number as shown in Figure 5.
4. Multiple calling at a time: The device can call automatically to multiple registered numbers. The details are shown in Figure 6.
5. Live Location: GPS module can be used to track live location of victim. It is shown in Figure 7.
6. Siren: Start buzzing under predetermined situations as shown in Figure 8.
7. Audible Live Voice: A mic is enabled to send voice of child to the registered number. The mimic is shown in Figure 9.
8. Back up: criminal details can be backed up for the future identification and tracking.

Following hardware components are used to design proposed system.

1. GPS Module.
2. GSM module
3. ESP32 Microcontroller / Arduino
4. GPS Antenna
5. Switch
6. Power convertor

Various components used are shown in Figure 10, Figure 11, Figure 12 and Figure 13.

**IMPLEMENTATION**

The actual hardware used in proposed IoT system is shown in Figure 14. The proposed system is made up with ESP32 microcontroller which is the most usable components in IoT projects nowadays. It requires SIM808 for sending SMS and power convertor from 5v to 3.3 v. It also has a switch which can be pressed by the victim. Figure 15 shows another variation of projects where SIM808 with GPS and GSM is used which also sends the longitude and latitude information in SMS. In Figure 16 the powering of the device is shown where ESP32 is powered with C type power cable. Victim can use pushbutton switch available on the product.

**CONCLUSION AND FUTURE SCOPE**

The device is the ultimate solution to offer security remotely. Through the effective use of the device, the crime rate against the children and woman can be decreased at very high extent. The parents can ensure and track their ward through mobile application which is connected to the security device. The device can work in bidirectional way too. If parents need to send some emergency signal to their ward, they can send some signal through mobile application. Evidence also can be generated against the criminal passively.

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**Kamini Solanki et al.,**

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**Table 1: Comparison of existing systems**

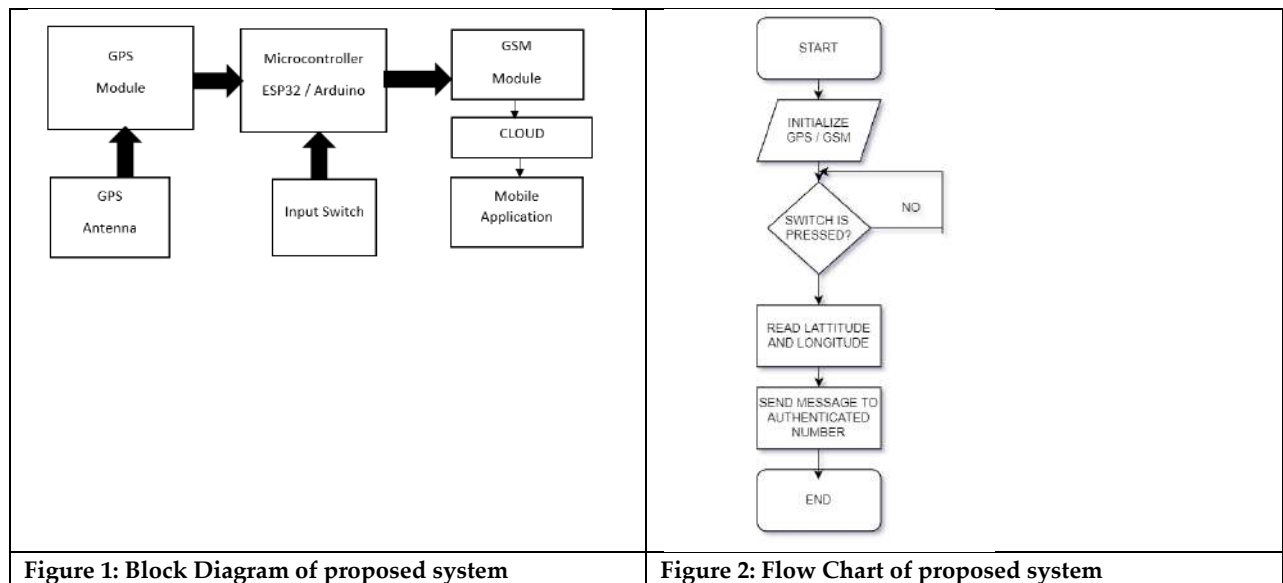
Sr.No	Device Name	Features	Drawbacks
1.	My HeroAlarm Device- optisafe.	<ul style="list-style-type: none"> <li>• Distress alarm device</li> <li>• Sleek design</li> <li>• Communicates SOS emergency</li> <li>• Collects evidence</li> <li>• The device locater helps you locate your paired smartphone &amp; app to locatethe device</li> </ul>	<ul style="list-style-type: none"> <li>• Trace the Live Location.</li> <li>• Emergency call via SOS</li> </ul>
2.	Women SafetyAlarm(Blue)	<ul style="list-style-type: none"> <li>• IP66 waterproof personal safety device</li> <li>• Small and portable, convenient for use in hand</li> <li>• Application for ladies, students, elderly, nightshift workers</li> </ul>	<ul style="list-style-type: none"> <li>• Alarm used only for nearby person.</li> <li>• SMS</li> <li>• Emergency call</li> <li>• Trace location</li> </ul>













**Kamini Solanki et al.,**

		emergency help.	<ul style="list-style-type: none"> <li>• SOS Facility.</li> </ul>
3.	Aryshaa NewAlarm	<ul style="list-style-type: none"> <li>• Alarm</li> </ul>	<ul style="list-style-type: none"> <li>• Backup</li> </ul>
4.	My Buddy DistressCompanion (SOS Tracker)	<ul style="list-style-type: none"> <li>• Multi-siren device.</li> <li>• SOS Message and Location.</li> <li>• In Built Location Tracker.</li> <li>• Audio/Video Recording</li> <li>• Device Locator</li> </ul>	<ul style="list-style-type: none"> <li>• Emergency calls.</li> <li>• Automatic calls</li> <li>• Persons trace location.</li> </ul>
5.	Grand Pit stop Emergency Women Safety Device with Alarm and Loud Noise on up to 130db	<ul style="list-style-type: none"> <li>• Strong alarm130 of dB.</li> <li>• alarm to call for immediate help.</li> </ul>	<ul style="list-style-type: none"> <li>• Automatic SMS.</li> <li>• Emergency calls.</li> <li>• Automatic calls.</li> <li>• Live Location.</li> </ul>
6.	Mark Safety Products High Pitch AutomaticAlarm with Wrist Band: Made in the United Kingdom	<ul style="list-style-type: none"> <li>• Mark has tied up with Salon Security.</li> <li>• A perior quality 130 dB Sound Alarm system is your lifetime friend.</li> </ul>	<ul style="list-style-type: none"> <li>• Automatic SMS.</li> <li>• Emergency calls.</li> <li>• Automatic calls.</li> <li>• Live Location</li> </ul>
7.	Mark Safety Products SafetyAlarm with Keying with LED for Womenand Children	<ul style="list-style-type: none"> <li>• generate an ear-splitting 130dB sound,</li> <li>• Capable of producing the blaring alarm sound</li> <li>• continuously for15 minutes.</li> </ul>	<ul style="list-style-type: none"> <li>• Automatic SMS.</li> <li>• Emergency calls.</li> <li>• Automatic calls.</li> <li>• Live Location</li> </ul>





**Kamini Solanki et al.,**

<div style="text-align: center;">  <p><b>Step 1: Registration</b></p> <p>Register your parents/relatives mobile number to our android app for emergency call when you are in trouble.</p> </div>	<div style="text-align: center;">  <p><b>Step 2: Voice Sensing</b></p> <p>we can embed the chip with Child's handwristwatch or belt. It senses the body temperature, heart beats or voice like "Help....., Mummy, papa, Hummm".</p> </div>
<p><b>Figure 3 Registration</b></p>	<p><b>Figure 4 Voice Sensing</b></p>
<div style="text-align: center;">  <p><b>Step 3: SMS</b></p> <p>It sends SMS to the registered mobile numbers.</p> </div>	<div style="text-align: center;">  <p><b>Step 4: Multiple Calling at a Time</b></p> <p>Smart Device can automatically multiple calling to the registered, parents and helpline no.</p> </div>
<p><b>Figure 5 SMS</b></p>	<p><b>Figure 6 Multiple Calling</b></p>
<div style="text-align: center;">  <p><b>Step 5: Live Location</b></p> <p>one can trace the location of victim using GPS</p> </div>	<div style="text-align: center;">  <p><b>Step 6: siren</b></p> <p>starts siren when it senses voice like "Help....., Mummy, papa, Hummm".</p> </div>
<p><b>Figure 7 Live Location</b></p>	<p><b>Figure 8 siren</b></p>
<div style="text-align: center;">  <p><b>Step 7: Audible Live Voice</b></p> <p>Parents can listen live voice of child through mic.</p> </div>	<div style="text-align: center;">  </div>
<p><b>Figure 9 Audible Live Voice</b></p>	<p><b>Figure 10: GPS with GSM Module</b></p>





**Kamini Solanki et al.,**



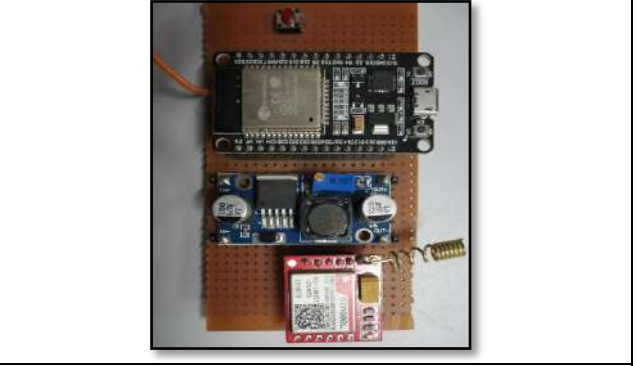
**Figure 11: ESP32 Microcontroller**



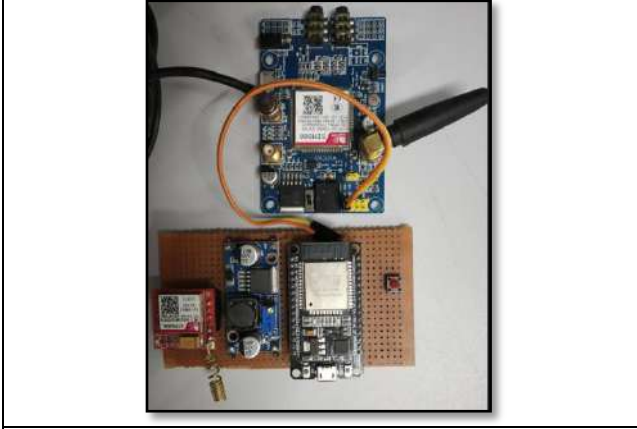
**Figure 12: GPS Antenna**



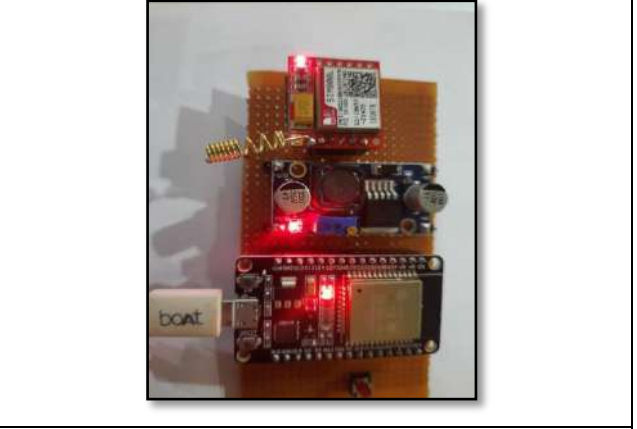
**Figure 13: Power Converter**



**Figure 14: GSM with ESP32**



**Figure 15: GPS and GSM with ESP32**



**Figure 16: Powering the device**





## Chargers for Solar and E-Vehicles

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### ABSTRACT

In view of the diminishing non-renewable energy sources such as coal and diesel, renewable energy sources have turned out to be a necessity for the future. These renewable sources include wind energy, solar energy, hydro-power, tidal energy and biomass, with solar energy being the most comprehensible, directly sourced from the sun. Photovoltaic cells convert solar energy to electrical energy, and this energy is stored in batteries for consumption during the dark hours. Solar-powered equipment and applications are in height request, and in order to charge batteries, solar charge controllers are utilized. However, traditional charge controllers employing the PWM technique are incompetent and can cause destruction to the batteries. To augment the performance of solar charge controllers, MPPT-based systems are used to transfer maximum power from solar panels to batteries. This paper proposes a use of a microcontroller-based system to safeguard a constant output from the solar panel under fluctuating environmental conditions. On the other hand, the use of an AC to DC charger as a reliable backup option for a solar MPPT charge controller is also considered. The AC to DC charger can come in accessible situations where there is insufficient sunlight to charge the battery or in cases of emergencies where the solar panels are not available.

**Keywords:** solar, MPPT, analog, digital, charger







Hitarth Solanki et al.,

## INTRODUCTION

A solar panel, also known as a photo-voltaic (PV) module, is made up of photo-voltaic cells arranged in a framework for installation. These panels consume sunlight to produce direct current electricity. The process involves converting light energy from the Sun (photons) into electricity through the photovoltaic effect. The cells are typically linked in series, then in parallel to boost the current and achieve the desired voltage. The power output of the module is calculated by multiplying the voltage (in volts) by the current (in amperes). It's important to note that the manufacturing specifications for solar panels are measured under standard conditions, which may differ from the actual operating conditions at the installation site. The complications with solar bicycles that are presently facing numerous challenges that limit their practicality and extensive use comprise of limited power output, limited battery capacity, weight and space limitations, cos and weather dependence. Owing to the weight and size limitations of solar panels on bicycles, it is not practicable to use larger solar panels. When solar panels are shaded, it can lead to a decrease in the power output of the entire panel. Even if a small portion of the panel is shaded, it can significantly reduce the efficiency of the entire panel. The weather dependence of solar panels mounted on bicycles can limit their effectiveness, especially during cloudy or rainy weather conditions. Addressing these challenges will be key to improving the viability and adoption of solar bicycles as an ecological mode of transportation. Solar panels have become progressively prevalent in recent years due to their capability to produce renewable energy and reduce reliance on fossil fuels. They are also environmental friendly and emit no emissions or pollutants. Additionally, advances in technology have made solar panels more efficient and cost-effective. The main objective of this paper is to ensure efficient battery charging by constantly extracting the maximum power output from the solar panel while also providing monitoring and control features. This helps to ensure the safety, reliability and longevity of the solar power system. Also to provide a reliable backup power source for the solar power system, ensuring that the battery is always charged even in low sunlight and various environmental conditions.

### SOLAR CHARGE CONTROLLER

The primary role of a battery charge controller is to manage the flow of electricity from the PV generator to the battery by means of regulating the voltage and current from the PV array. Its key objective is to avoid the battery from being overcharged or over-discharged. There are four general types of charge controllers

1. Shunt type charge controllers
2. Series type charge controllers
3. Pulse-width modulation charge controllers
4. MPPT charge controllers

Small PV arrays use Shunt and Series type of charge controllers as the basic charge controllers. For a more efficient method to charge the battery broadly there are two different topologies of solar charge controller available:- Pulse Width Modulation (PWM) and Maximum Power Point Tracker (MPPT).

### Pulse Width Modulation (PWM)

The PWM controller is basically a switch that links a solar array to the battery. The result is that the voltage of the array will be pulled down to near that of the battery. The PWM topology is a cost-effective option for solar charge controllers commonly utilized in solar home light or home power systems. In a solar power system, the solar PV module/array is connected to the battery continuously, and the charge controller is responsible for adjusting the higher voltage of the solar PV array to match the battery terminal voltage. During the charging process, as the battery voltage increases, the charge controller ensures that the solar array output voltage is always higher than the battery voltage. The PWM charge controller is an affordable option and is widely used in off-grid solar solutions for households and commercial applications. When using a 12V battery, a 12V solar panel can be used to charge it. To charge a 24V battery bank, either two 12V panels wired in series or a single 24V panel is required, and so on. To ensure efficient charging, the PWM charge controller requires the voltage of the panel array to match that of the battery bank. If there is a mismatch in voltage, there will be a loss of charging power, and the greater the mismatch,







### Hitarth Solanki et al.,

the greater the power loss. Therefore, while PWM is a cost effective and affordable option, it is less flexible and efficient than other charge controller options.

#### Maximum Power Point Tracker (MPPT)

The MPPT controller is more sophisticated (and more expensive) but offer greater flexibility in terms of the number of panels. It adjusts its input voltage to yield the maximum power from the solar array and transform it to supply the fluctuating voltage requirement of the battery as well as the load. With MPPT controllers, the voltage from the PV module drops down, which corresponds to an increase in current to match the battery bank. This increase in amperage results in a faster recharge. These controllers automatically adjust as per the  $P = V \times A$  equation, providing more power to charge the battery, with no loss of power unlike in PWM. The benefits of MPPT are as follows:

1. The MPPT controller allows a panel array to be of higher voltage than the battery bank. This is applicable to areas with low irradiation or during winter wherein fewer hours of sunlight is available.
2. They provide an increase in charging efficiency up to 30% compared to PWM.
3. Greater flexibility for system growth. This is appropriate for commercial establishments.
4. They typically come with higher warranty periods than the PWM type.

MPPT strategies can be classified in different ways: Based on the number of variables used to track MPP, such as one or two variable methods and Based on the type of techniques used to track MPP, which can be broadly categorized into three groups: Offline (indirect), Online (direct) and other techniques. Offline control techniques estimate the MPP using technical data of PV panels, such as I-V and P-V curves for different climatic conditions and mathematical models of PV panels. In contrast, online methods track MPP using real-time PV voltages and/or current measurements, without requiring temperature and solar irradiance measurements or a PV array model. Other methods include modifications or combinations of these methods, or indirect calculations. Although offline methods are cost-effective, they may be less effective in terms of performance compared to online and other methods.

#### Different Techniques to determine MPP Point

There are different techniques used to track the maximum power point. Few of the most popular techniques are:

1. Perturb and observe
2. Incremental Conductance method
3. Ripple correlation

The MPPT charge controller converts the solar panel's output voltage to the appropriate voltage for charging the battery. The battery is connected to the MPPT charge controller, which controls the amount of current flowing into the battery to prevent overcharging and ensure the battery is charged to its full capacity. The motor controller regulates the electrical energy flowing from the battery to the motor to control the speed and direction of the motor.

#### MPPT charge controller includes

1. Boost converter :- To boost the voltage for charging the battery.
2. Hybrid control circuit :- To maintain the input voltage at maximum power point.

#### Boost Converter

The boost converter utilized herewith consists of UC3843 (current mode PWM controller IC) which can easily control the duty cycle of the MOSFET depending upon the feedback. The UC3843 IC requires at least 9V input to operate thus, a voltage regulator is also provided. Initially, the boost converter was provided with feedback from the output side. The feedback was directed to Pin 2 of the UC3843 IC via a resistor divider, resulting in a constant voltage of 2.5 V at Pin 2. By manipulating the potentiometer, the output voltage could be adjusted while maintaining the voltage at Pin 2 at 2.5 V. However, to regulate the solar panel voltage and achieve maximum power point tracking (MPPT) for battery charging, feedback from the output was replaced with feedback from the solar panel through a separate circuit. By taking feedback from the solar panel, the IC controls the MOSFET switching to obtain maximum power from the solar panel at any given moment for battery charging. Given that the solar panel voltage is 12V and the





**Hitarth Solanki et al.,**

battery voltage is 36V-42V, a boost converter with feedback control was employed to raise the input voltage above the battery voltage, enabling MPPT for battery charging.

### FEEDBACK CONTROL THROUGH ANALOG CIRCUIT

The design of an analog circuit is to give the feedback to Pin 2 of the UC3843 IC of the boost converter such that we can control the voltage of the solar panel and we can fix the voltage of the solar panel where we get maximum charging current. This analog circuit consists of LM358 dual Op-Amp, 6.8V zener diode, potentiometers and resistors.

#### Working of analog circuit

Input to this circuit is taken from the solar panel. The solar panel gives 22V maximum voltage supply which is further given to the zener diode and the Op-Amp through resistors. Herein, a 6.8V zener diode is used to give a constant supply voltage to the Op-Amp. The zener diode requires a minimum of 5 mA current to break-down so accordingly the resistor values are set to obtain 6.8 V across zener diode. In this case, the solar panel voltage changes from 14V to 22V. According to different voltage values, the value of the resistor is calculated as shown below

At  $V_s = 22V$ ,  $R_z = (22 - 6.8)/5 \text{ V/mA} = 3.04 \text{ k-ohm}$  At  $V_s = 18V$ ,  $R_z = (18 - 6.8)/5 \text{ V/mA} = 2.24 \text{ k-ohm}$

As the zener diode needs 5 mA or more current through it, the value of the resistor selected is less than 2.24k ohm in series with the 6.8V zener diode. The circuit also consists of an Op-Amp which is configured to operate in the inverting mode to achieve the desired inverting feedback. In this mode, the input is applied to the inverting input terminal of the Op-Amp, while a reference voltage is applied to the non-inverting input terminal. The reference to the non-inverting terminal is provided using a voltage divider to divide the voltage of the zener diode into half the value and provide the same to the non-inverting terminal. Hence, the voltage at the non-inverting reference terminal being 3.4 V. The input signal to the inverting terminal is derived from the solar panel through a voltage divider comprising a 10 k-ohm potentiometer and a 4.7 k-ohm resistor in series. The voltage drop across the 4.7 k-ohm resistor is fed into the inverting terminal via a 10 k-ohm resistor, which allows the Op-Amp output to be set at 2.5 V. To achieve unity gain, a feedback resistor of 10 k-ohm is selected across the Op-Amp. The gain of the Op-Amp can be calculated using the following formula

Gain,  $A = R_f / R_{in} = 10 \text{ k-ohm} / 10 \text{ k-ohm} = 1$  (unity gain) where  $R_f$  = feedback resistance  $R_{in}$  = Input resistance

The output from the Op-Amp is given to the voltage feedback pin (Pin 2) of the UC3843 IC of the boost converter. When the value of the 10 k-ohm potentiometer is adjusted, the voltage drop across the 4.7 k-ohm resistor will change accordingly, leading to a change in the output voltage of the Op-Amp from 2.5V to a different value. This change in Op-Amp output voltage will be perceived by the UC3843 IC as a change in the load and trigger an adjustment in the duty cycle of the MOSFET. This adjustment in turn will alter the voltage output of the solar panel.

#### Issues in Analog Circuit

When using an analog circuit, it is necessary to periodically adjust the potentiometer value to achieve the MPP point for a solar panel, as the MPP point changes over time. However, requiring users to manually make these adjustments is not a practical solution for charging a battery. To address this issue, a feedback control circuit utilizing a microcontroller unit is developed to regulate the voltage of the solar panel and maintain the MPP point automatically.

### FEEDBACK CONTROL THROUGH DIGITAL CIRCUIT

Feedback control through a digital circuit involves using a microcontroller or other digital control system to monitor and adjust the output of a system based on input signals. The digital circuit utilizes an LPC802 microcontroller, which has a minimum operating voltage of 3.3 V and a maximum of 5 V. To ensure that the microcontroller is not damaged, we have incorporated a 3.3 V regulator (LM358) to provide a constant supply to the microcontroller. The input to this circuit is sourced from a solar panel and is first fed into a 9V regulator, which is connected to a boost



**Hitarth Solanki et al.,**

converter. The output of the boost converter is then supplied to the UC3843 chip, which in turn generates a 9V output that is supplied to the LM358 regulator. The LM358 regulator then provides a regulated 3.3V output to the microcontroller (LPC802). To measure the charging current of the battery, a 0.5 ohm resistor is incorporated in the circuit. The current flowing through this resistor generates a voltage that is measured to determine the charging current. This voltage is fed into the microcontroller as an input, but since the voltage corresponds to an analog value, it needs to be converted to a digital value using an ADC conversion. As the microcontroller only operates on digital values, this conversion is necessary. However, ADC conversion requires some time to convert the analog values into digital values. The feedback loop of the boost converter's UC3843 IC is connected to Pin 1 of the microcontroller as a PWM value. This PWM value changes based on the microcontroller's output, causing the voltage at Pin 2 of the UC3843 IC to vary from 2.5 V to another value. This variation is interpreted by the UC3843 IC as a change in the load, and it adjusts the duty cycle of the MOSFET accordingly, leading to a change in the solar panel voltage. The microcontroller records various charging current values and determines the PWM value at which the charging current is highest.

### Issues in Digital Circuit

During the process of determining the MPP point using coarse and fine plot methods, there may be instances where the voltage value drops abruptly to 0V. Afterwards, it takes some time to return to the starting value and to find the MPP point again. The reason behind this behavior is that while finding the MPP point digitally, there is a delay due to the time taken for ADC conversions. Additionally, fast feedback action is required to keep the voltage value close to the MPP point during the process of finding it. This is because when the boost converter demands more power from the solar panel, it causes the voltage value to drop to 0V or to the minimum operating voltage of the boost converter. As it takes considerable time to find the MPP point digitally and maintain a fast feedback action to remain near it, this approach is not efficient for charging the battery. A constant power near the MPP point is required for proper charging, which is not achieved with the current method.

### FEEDBACK CONTROL THROUGH HYBRID CIRCUIT

Both individual circuits had their own issues, so the decision was made to combine them. It was observed that relying solely on a digital circuit was not effective in efficiently charging the battery since it was not able to consistently provide maximum power. On the other hand, the analog circuit lacked the ability to independently alter the input voltage. It was decided to create a hybrid circuit that combines both analog and digital circuits to improve the accuracy of the feedback mechanism and charge the battery more efficiently. As it was not possible to provide feedback from both the analog and digital circuits simultaneously, it was decided to use the analog circuit's Op-Amp as a summing amplifier. By doing so, it was able to combine the outputs of both circuits and feed them as a single input to the voltage feedback pin of the UC3843 IC of the boost converter.

The analog circuit was used for fast feedback action to communicate with the boost converter more efficiently, while the digital circuit was used to give small inputs to the analog input to find the exact MPP point at every instant automatically. The analog circuit charges the battery near the MPP point continuously, ensuring that the solar voltage never drops down to 0V. With this hybrid approach, the battery can be charged more efficiently and quickly. To achieve an output voltage of 2.5V for the voltage feedback pin of the UC3843 IC, calculations were performed to determine the values of resistances required. With an aim to maintain a constant current flow through the feedback resistance ( $R_f$ ), the input resistances for the analog and digital circuits were calculated in a way that the current coming from the analog circuit would be divided between the digital and feedback resistance. By setting the values of  $R_1$  and  $R_2$  to 10 k-ohm and 14.7 k-ohm, respectively, any change in the analog current will result in a proportional change in the digital current, while the current in the feedback resistance remains constant. The L6562A is a current-mode PFC controller from STMicroelectronics designed for high-performance, low-cost offline PFC applications. LED driver circuits are used to provide the correct voltage and current to an LED for it to function optimally, efficiently, and safely. They also provide dimming control for LED lighting systems and can improve the overall energy efficiency of the system.





Hitarth Solanki et al.,

### Advantages of Designing a Combined Analog and Digital Circuit PCB

1. **Reduced signal interference:** By combining the analog and digital circuits onto one PCB, the distance between the circuits is minimized, reducing the possibility of interference between them. This results in better overall performance and reduced noise.
2. **Lower cost:** By combining the analog and digital circuits onto one PCB, the cost of manufacturing is reduced. There is no need for separate boards, connectors and cables.
3. **Improved reliability:** With a compact PCB design, the distance between components is reduced, which reduces the length of the traces and connections between them. This leads to less interference, improved signal integrity, and better overall reliability.
4. **Space-saving:** Combining the analog and digital circuits onto one PCB saves space, making it easier to fit the circuit into a smaller enclosure or device.
5. **Easier assembly:** A compact PCB design makes it easier to assemble the circuit, reducing the time and cost of production. Additionally, by having both circuits on one PCB, the testing and troubleshooting process is simplified, making it easier to identify and fix any issues that may arise.

### Software and Debug tools

1. **MCUXpresso IDE:** The MCUXpresso IDE is a user-friendly integrated development environment that combines the best features of the LPCXpresso and Kinetis Design Studio IDEs for Kinetis and LPC MCUs. It provides basic editing, compiling, and debugging features, as well as MCU-specific debugging views, code trace and profiling, and multicore debugging.
2. **KiCAD :** The KiCAD software, specifically the Eeschema schematic editor and the PCBnew PCB layout software, were used to implement the project.

Firstly, all the components were placed on the schematic sheet with their appropriate connections to pins and nets. Each component was then assigned its respective footprint and a Design Rule Check (DRC) was performed to ensure that no errors were made. Next, a netlist was generated and uploaded to PCBnew. This generated all the footprints and ratline connections. The footprints were adjusted for proper spacing and dimensions, and traces were used to connect them. An edge cut was then placed around the footprints to define the shape of the shield. The board was filled with the ground plane using the fill-in area tool and another DRC was performed to ensure that there were no errors. Finally, the gerber files were exported for future use.

## CONCLUSION

The implementation of Maximum Power Point Tracking algorithm in solar charge controllers enhances their charging efficiency and reduces the charging time. The utilization of hybrid circuits consisting of both analog and digital components also enhances the performance of charge controllers. This solar charge controller is cost-effective and practical for any consumer, as it operates on solar energy and can save money on electricity bills while being environmentally friendly. The combination of e-cycles and solar energy can prove to be beneficial in the future, especially with the increasing prices of petrol and the demand for electricity due to coal shortages. The AC to DC charger serves as a reliable backup option for the solar MPPT charge controller in situations where there is insufficient sunlight or during emergencies when solar panels are not available. Overall, the use of MPPT charge controllers and AC to DC chargers can greatly enhance the efficiency and convenience of charging e-cycle batteries, making them a more practical and sustainable mode of transportation.

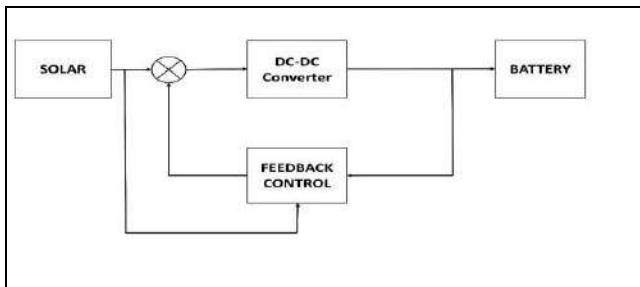




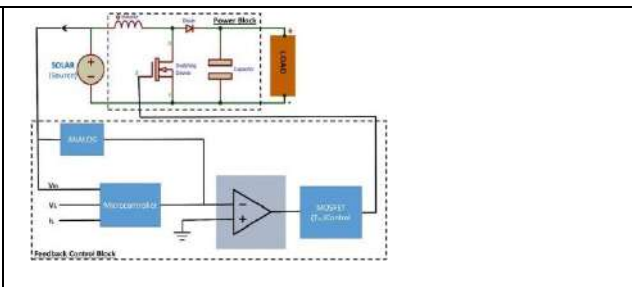
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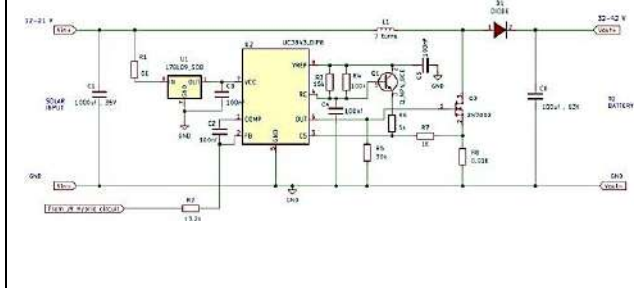
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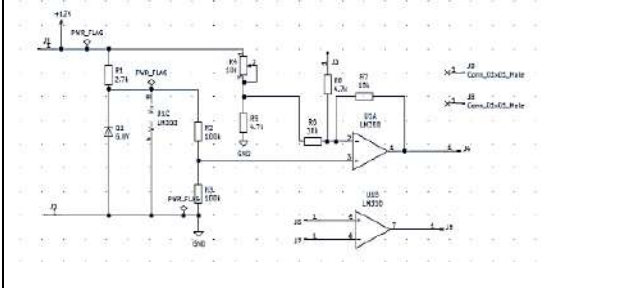
**Fig1. Block Diagram of MPPT Charge Controller**



**Fig 2 Power & Feedback control block**



**Fig 3 Boost converter circuit with UC3843**



**Fig 4 Analog Circuit for Feedback**







Hitarth Solanki et al.,

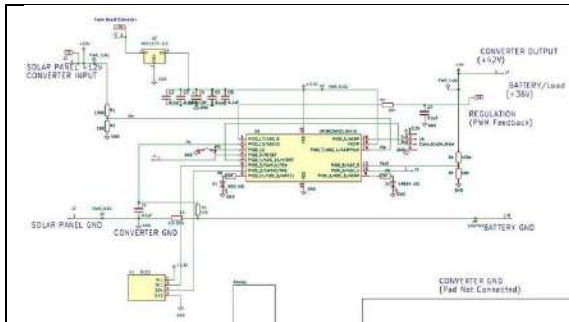


Fig 5 Digital Circuit for Feedback

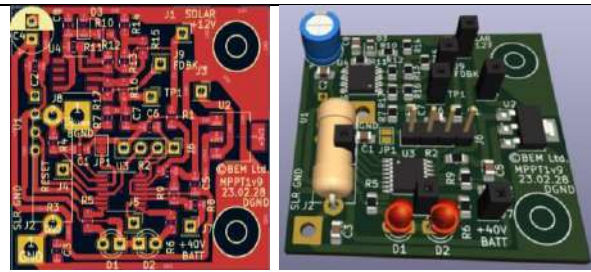


Fig 6 (a).Hybrid circuit PCB layout (b) Hybrid circuit 3D view

$$Z = \text{softmax}\left(\frac{QK^T}{\sqrt{d_k}}V\right)$$



Fig 7 (a.)Front View (b) Rear View (c) Enclosed View of Hybrid circuit







## A Sustainable Approach for Pollution-Free Mobility: Green Airport

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### ABSTRACT

The aviation industry is one of the most important industries. The aviation sector provides the global transportation network, making it essential for global business and tourism. It plays an important role in economic growth and poverty alleviation. The aviation industry is expanding rapidly and will continue to grow in the future. According to ICAO estimates, air traffic will increase by an average of 4.3% per year over the next 20 years. One of the most important areas of activity in the aviation sector is airport management. Airports are critical nodes in the transportation system and also in territorial connectivity. Airports provide airline services, passenger transportation, and freight transportation. Although the airport's positive impacts are taken into account, airport operations have various impacts on local communities and the natural environment. Airport activities can negatively impact the environmental quality of the surrounding area. This paper aims to propose a solution for designing green airport infrastructure. Eleven key elements that are crucial for developing green airports have been chosen as the paper's core criteria in order to achieve its goal. Through the use of a questionnaire survey form, responses from 61 respondents were gathered, and an analysis was performed. Utilizing sustainable airport construction techniques while planning, constructing, running, and monitoring can help protect the environment and lower pollution.

**Keywords:** Green airport, Sustainable, Air transport.





Jagruti Kautkar et al.,

## INTRODUCTION

Transportation is an important factor for the social and economic development of any region or country. It is very difficult to imagine society without any mode of transportation. The aviation sector is one of the fastest growing in transportation as the world economy becomes increasingly interconnected. Overtime, there has been a tremendous expansion of the global air transport sector. For international trade and tourism, air travel is essential since it offers the only quick worldwide transportation network. On both local communities and the environment, airport activities have a number of effects. Noise, neighborhood air quality, energy consumption, water use, and garbage generated at the airport are some of these effects. According to the Carbon Footprint of Indian Aviation Report by the DGCA (Directorate General of Civil Aviation, Government of India), approximately 35 million tonnes of CO<sub>2</sub> emissions world wide were produced by airport operations in 2013; this represents 5% of the total CO<sub>2</sub> emissions produced by the entire aviation industry. In 2013, around 0.78 million tonnes of CO<sub>2</sub> emissions were produced by Indian airports. Thus, it becomes clear that it is critical to preserve, control, and lessen the environmental harm caused by the aviation sector. Sustainability is the capacity to exist and advance without consuming current or future natural resources. Sustainable development satisfies existing demands without jeopardizing the capacity of future generations to satisfy their own needs.

Although there are many ways to interpret the idea of sustainable development, at its core it refers to a method of growth that seeks to strike a balance between various, frequently incompatible needs and an awareness of the social, economic, and environmental constraints that our society is subject to. All too frequently, development is fuelled by a single demand without adequately accounting for its wider or longer-term effects. The harm that may emerge from this sort of strategy is already becoming apparent, from the large-scale financial crises brought on by reckless banking to the changes in the planet's climate brought on by our reliance on fossil fuel-based energy sources. We must act now because the longer we pursue unsustainable growth, the more probable it is that its effects will become frequent and severe. A common roadmap for peace and prosperity for people and the planet, both now and in the future, is provided by the 2030 Agenda for Sustainable Development, which was accepted by all United Nations Member States in 2015. The 17 Sustainable Development Goals (SDGs), which represent an urgent call to action for all nations—developed and developing—in a global partnership, are at the center of it. They understand that eradicating poverty and other forms of deprivation requires concerted efforts to combat climate change, protect our seas and forests, enhance health and education, and lower inequality in addition to promoting economic growth. The Sustainable Development Goals (SDGs) are a collection of 17 global goals established by the United Nations General Assembly in 2015. These goals are designed to be a "universal call to action to end poverty, protect the planet, and ensure that all people enjoy peace and prosperity by 2030." The SDGs address various social, economic, and environmental development challenges faced by countries around the world.

### WHAT IS GREEN AIRPORT

The term "Green Airport" generally refers to an airport that adopts environmentally sustainable practices and aims to minimize its impact on the environment. A green airport focuses on reducing energy consumption, promoting renewable energy sources, managing waste efficiently, and implementing eco-friendly initiatives throughout its operations. A green airport is an aviation facility that prioritizes environmental sustainability by implementing measures to minimize its carbon footprint, conserve resources, and protect natural ecosystems. It aims to balance the economic benefits of air travel with a commitment to environmental responsibility. Airport sustainability is a "holistic approach to managing an airport so as to ensure the integrity of the economic viability, operational efficiency, natural resource conservation, and social responsibility of the airport," according to the Airport Council International (ACI) ([www.aci-na.org](http://www.aci-na.org)). In order to encourage environmentally friendly green building design and construction, ASSOCHAM established the Council for Green and Eco-friendly Movement (CGEM), which administers the "GEM Sustainability Certification Programme." AAI's Chennai International Airport and Vadodara





Jagruti Kautkar *et al.*,

Airport received Platinum awards from the ASSOCHAM GEM Green Building Council on November 20, 2020, for their sustainable green initiatives.

### OBJECTIVE OF THE RESEARCH

The objective is to study current green airports around the world as well as the key criteria for green airport construction infrastructure were among the goals and also recommending environmental best practices to reduce aviation's environmental impact and suggesting sustainable methods for future use.

### METHODOLOGY

Although airports and aviation benefit the social and economic well-being of everyone involved, they also have a significant detrimental influence on the environment. The implementation of an ecologically friendly airport concept is one effort to take environmental considerations into account when conducting airport operating operations. The research's components were arranged using the significance index approach, which allowed for the computation of each factor's significance index and ranking of the elements based on overall comparison. Based on the literature assessment, 11 Main Parameters that are regarded as key indicators were chosen for this issue. 61 experts responded to the questionnaire, which was created. The questionnaire was designed for 11 primary factors and had a total of 56 sub-parameters. The 61 experts' responses were compiled, and analysis was done using SPSS. The data gathered was put to use ranking each need while an ecologically friendly airport infrastructure was being developed. The first five major factors were suggested after further examination of the requirements. Figure 5 illustrates the relative importance of the important parameters through a graphical depiction of the expert-collected replies. The RII rank approach was used to analyse the sub parameters under the major parameters, and the rank for each sub parameter to be taken into account while planning for green airport infrastructure was calculated. The RII ranking approach enables decision-makers to create a prioritized list of products or alternatives by taking into consideration the ratings of numerous criteria and their relative relevance' It is an effective technique for evaluating many choices and coming to well-informed judgments based on the unique needs and preferences of the decision-makers. This means that preferences "5," "4," "3," "2," and "1" have significance indexes of most essential, very important, important, moderate and less respectively.

#### Rank Importance Index (RII) method

$$RII = \frac{5*n_5 + 4*n_4 + 3*n_3 + 2*n_2 + 1*n_1}{A*N}$$

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Where, RII = Rank Importance Index

n5 = Number of respondents for Most Essential

n4 = Number of respondents for Very Important

n3 = Number of respondents for Important

n2 = Number of respondents for Moderate

n1 = Number of respondents for Less

A = Highest weight (5)

N = Total number of respondents (61)

Figure 6 displays the relative importance index (RII) method ranking for the parameters. The rating was created in order to understand clearly which aspects should be taken into account when designing or planning a green airport. Recommendations for the first five parameters, ranked, were given for the research project.

### RECOMMENDATIONS

The study's discovered variables are regarded as the primary variables to take into account when constructing any green airport infrastructure. The study offers recommendations for the first five parameters that were investigated for this study using SPSS. The software produces a ranking for each element and groups them according to the ranking, indicating which parameter is the most important to take into account when planning Green Airport.





Jagruti Kautkar et al.,

Figure 5 demonstrates that the primary factor that should be taken into account the most when planning an airport is emission reduction and air quality. Airports can take a number of actions to lower emissions and increase sustainability. Important things to watch out for are sustainable aviation fuel, sustainable ground transportation, energy-efficient infrastructure, renewable energy, waste management and recycling, green procurement, etc. According to a study, planting shrubs including *Frankenia thymifolia*, *Vinca major*, *Sedum acre*, and bamboo will reduce CO<sub>2</sub> emissions. Airports should also get ready for a water management strategy. Using techniques like permeable pavements, retention ponds, wetlands restoration, water-efficient landscaping, and cutting-edge drainage systems, water management is incorporated into green airport planning. Other important factors to take into account while planning a green airport include waste management, water pollution, and energy management. Additionally, airports can register with the Green Building Rating System, which will guide them and promote the adoption of better practices. Resource conservation, energy efficiency, and environmentally friendly practices in airport planning, development, and operation are to be evaluated and promoted through these rating systems. BREEAM Infrastructure, Eco-Airport Certification, Green Building Index (GBI), and Leadership in Energy and Environmental Design (LEED) Airport Certification are some examples of exemplary green rating systems for green airport infrastructure.

## CONCLUSION

Airport buildings should be designed to satisfy sustainability standards in order to reduce all of these effects. Creating green airports might benefit the cause. A green airport in one, meeting the latest sustainability criteria, reducing the impact of airport activities on the environment, and mitigating the impact of climate change on associated facilities and operations. Sustainable growth of airports requires that they be developed as inter-modal transport hubs as part of an integrated public transport network. The ground infrastructure development should include low emission service vehicles, LEEDS certified green buildings with low energy requirements, and recyclable water usage. There should be effective land use planning of the area around the airports (including securing land for future development) with active investments into the surrounding communities. Airport expansion must also consider the issue of noise and its impact on the surrounding communities, and should be involved in its mitigation by engaging in the flight path design. The air quality near the airports should be monitored and measures for its continuous improvement should be put in place. In addition, there should be regulatory requirements to set risk limits.

## LIMITATION OF STUDY

For the purpose of the current study, 11 parameters and 56 sub parameters were chosen for consideration while building environmentally friendly airport infrastructure, but only the first 5 parameters' solutions were offered. The ranking was carried out using the SPSS programme, and the top 5 were recommended. The remaining 6 factors might be recommended by utilizing various methods.

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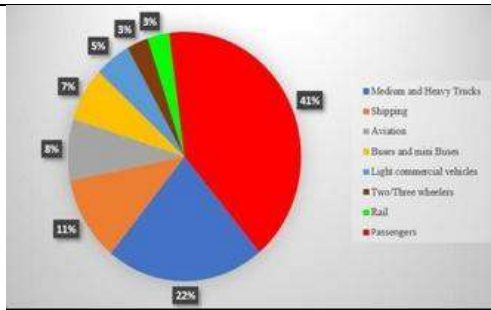


Figure 1: Global Transport GHG emissions

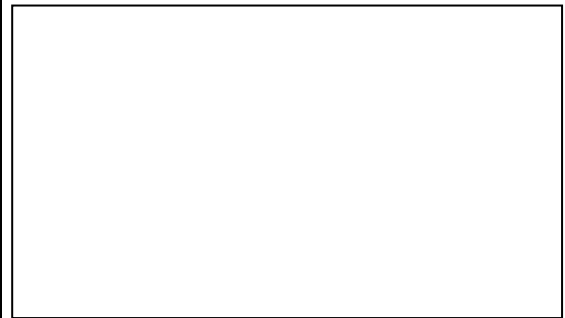


Figure 2: Sustainable Development Goals (SDGs)

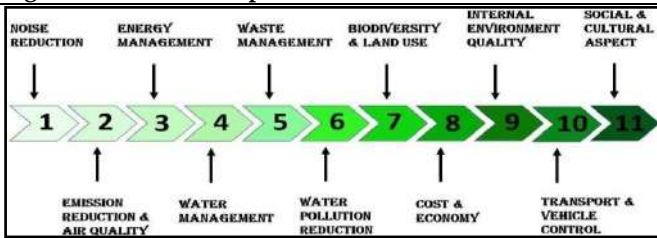


Figure 3: Parameters for Green Airport planning

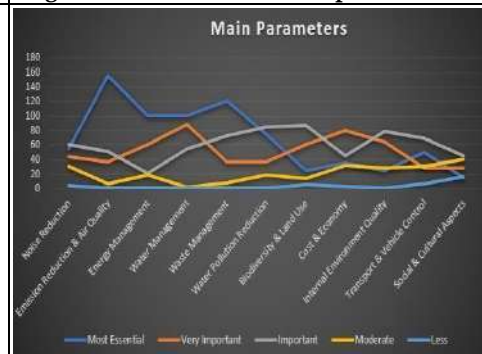


Figure 4: Main parameter analysis

Question	Most Essential	Very Important	Important	Moderate	Less	RII	Rank
Noise Reduction	55	44	60	30	4	0.63 27	8
Emission Reduction & Air Quality	155	36	51	6	1	0.81 63	1
Energy Management	100	60	21	19	0	0.65 57	5
Water Management	100	88	54	2	0	0.8	2
Waste Management	120	36	72	8	0	0.77 37	3
Water Pollution Reduction	75	36	84	18	0	0.69 83	4
Biodiversity & Land Use	25	60	87	14	5	0.62 62	9
Cost & Economy	35	80	45	32	3	0.63 93	6
Internal Environment Quality	25	64	78	28	0	0.63 93	7
Transport & Vehicle Control	50	28	69	30	6	0.6	10
Social & Cultural Aspects	15	28	45	40	16	0.47 21	11

Figure 5: RII analysis







## Real Time Parking System Using IoT

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### ABSTRACT

This article introduces a groundbreaking solution to address the challenges posed by the rapid increase in vehicle ownership in countries like India, China, and Russia: a real time smart parking system leveraging the Internet of Things (IoT). Existing parking systems suffer from limitations such as insufficient differentiation between parking spaces and a reliance on human intervention. In response, this research proposes an automated parking management system that employs IoT sensors and internet-connected devices to enable real-time detection, prediction, and optimization of parking spaces. The system's scope encompasses real-time vehicle detection, occupancy monitoring, parking direction and navigation, and enhanced security, offering numerous benefits including reduced traffic congestion, enhanced user experience, and environmentally friendly solutions. This report highlights the potential of IoT-based smart parking systems to revolutionize urban parking management and create more accessible and sustainable urban environments.

**Keywords:** Internet of Things (IoT), Microcontroller, Sensors, Parking system, Automation

## INTRODUCTION

In countries, like India, China and Russia the rapid increase in vehicle ownership has brought about challenges in urban transportation. In a nation known for its road network the fiscal year 2022 represented a milestone with an astounding 326.3 million vehicles hitting the streets (source). The growing automobile markets have witnessed a surge in the number of vehicles on the roads resulting in pressing parking issues that often lead to traffic congestion within major cities. This influx of vehicles does not cause daily commuting difficulties. Also, directly and indirectly contributes to high fuel consumption, primarily petrol and diesel. To address these challenges our research aims to introduce a smart parking system that leverages the potential of the Internet of Things (IoT). As we delve into existing research on this topic it becomes clear that although significant progress has been made in developing



**Viranchi Pandya et al.,**

parking systems there are still gaps and limitations. Many current systems struggle with issues like parking, in designated spaces and situations where multiple motorcycles occupy single slots meant for cars (Nimble et al., 2016). It can be difficult to differentiate between parking spaces that are reserved and those that are not. One issue that stands out is the lack of administrative control panels, with user interfaces (GUIs) to address real time problems (Shree, 2017). Moreover, a substantial degree of human intervention is frequently necessary to ensure the seamless operation of these systems. Motivated by these challenges and the opportunities they present for improvement we have proposed an automated parking management system, in our research. Our system utilizes sensors and internet connected devices to establish a network that enables real time detection, prediction and optimization of parking spaces. Through our research our goal is to offer a solution to the challenges arising from the rapid increase in the number of vehicles. We envision our system as a catalyst for creating sustainable and easily accessible urban environments. Our research highlights the power of technology in reshaping the future of parking management. Demonstrates our dedication to enhancing urban mobility and sustainability amidst an ever-evolving vehicular landscape.

**SCOPE OF THE PROPOSED IDEA**

An all-encompassing and cutting-edge solution for effective parking space management is provided by the real-time parking system based on deep-learning object identification and IoT sensors. The management of parking in metropolitan areas, business complexes, and public places will be revolutionized by including a variety of features and advantages. The following are the main facets of the system's scope.

**Real-Time Vehicle Detection**

A Real-Time Operating System is especially design to manage the execution of the task in real time. Unlike General Purpose Operating system they work well with hard real time systems, where missing the deadline or failure of the execution of certain task on time is catastrophic, meeting the timing and responsiveness requirements of embedded systems and critical applications. It provides a framework for managing, scheduling and synchronizing task and processes.

**Monitoring of Occupancy**

The system's connection with IoT sensors enables ongoing monitoring of parking spot occupancy. Through smartphone applications or digital displays, drivers and parking lot owners may get the most recent information on parking spaces that are open, saving time and effort.

**Parking Direction and Navigation**

Using mobile applications or in-car navigation systems, the system can direct cars to available parking spaces. It offers turn-by-turn guidance, which eases traffic and improves consumers' parking experiences in general.

**Security and surveillance**

IoT sensors and security cameras improve parking lots' security by lowering the likelihood of theft and damage. Additionally, the technology has the ability to identify cars that are unknown or questionable, immediately alerting security officers.

**LITERATURE SURVEY**

Cynthia J. [1] provides both users and parking area administrator, a smart auto parking system offers a complete parking solution. It offers the functionality of a reserved parking space and identifies the reserved user. Using this, the user may find the closest parking space based on the size of the car. Parking spaces can be reserved by the user on an hourly, daily, weekly, or monthly basis. An algorithm is created to determine the closest parking spot based on size. The user's mobile application is used to make reservations and pay-as-you-go service. Abhirup Khanna [2]



**Viranchi Pandya et al.,**

and colleagues developed this technique using a mobile application that is connected to the cloud. The user will decide on a time to assign the area. The user will be alerted if he doesn't interact later. The number of reserved and open parking spaces will be shown on the application. The disadvantage is that after a slot has been assigned, if another person asks for it later, he cannot allocate it to them, resulting in a loss of time, money, and space if the original user subsequently cancels. Hans et al.'s paper [3] suggests a parking and reservation system. When a customer enters the parking lot, the system will locate a free spot for them. To authenticate the car's owner and locate the closest parking space, image detection cameras are utilized to detect the number plate on the vehicle. The camera uses image processing, and the system also offers parking lot reservation services and payment through a payment wallet. The vehicle will occupy the specific space that has been assigned, according to the work of Fernando Rios et al. [4]. RFID sensors can identify whether a car or other things are nearby. The system requires a mechanism to alert drivers or parking spot occupants when a vehicle is spotted.

The drawback is that because there is no GPS sensor to look for parking spaces from a distance, the parking spot will only be identified in surrounding locations. Raspberry Pi was employed as a microcontroller and connected to an IR sensor as input in the study by Gavali et al. [5]. The Raspberry Pi will get data from the IR sensor after it has detected any cars. When parking is available, a green LED indication will illuminate, and a red LED will illuminate when a sensor detects the presence of automobiles. A real-time parking spot status update is done using an Android application. A detailed design and operation of an automated parking system utilizing RFID (Radio-frequency identification) technology is shown in this paper [6]. Finding vacant spaces, turning vehicles, and maintaining security are all made easier by this innovative smart auto parking system concept. The major goal of this parking system is to eliminate monitoring, which is undesirable in a conventional auto parking system, and prohibit cars from entering and leaving in the shortest amount of time feasible. The area is minimized by the automated system's single entrance and departure point, which eliminates the need for automobiles to perform any turns. Slots with rail-mounted support can move horizontally at an angle since there is only one semi-circular channel required for the car's entrance and exit. Every slot contains RFID tags. Kanteti Dharmini [7] devised an algorithm that makes use of hybrid parking techniques in order to successfully and efficiently park the car. This improves parking effectiveness while reducing operating and energy expenses. Here, they connected the components using an Arduino microcontroller, a Raspberry-Pi, OCR software, speed sensors, speed sensors to calculate speed, ultrasonic sensors to detect cars, and CMOS sensors to recognize license plates. The research emphasizes user safety guidelines in addition to efficient and productive smart working methods.

**IOT in Real Time Parking System**

The integration of Internet of Things (IoT) technology is a fundamental component of real-time parking management systems. IoT plays a crucial role in collecting and transmitting data related to parking space occupancy, enabling the efficient management and utilization of parking infrastructure. In this system, we use three types of sensors: ultrasonic sensors, PIR (Passive Infrared) sensors, and infrared obstacle sensors, along with two LEDs (Red and Green) to indicate the occupancy status of parking spaces. The integration of these components allows for efficient real-time parking space monitoring, and the data collected is processed using Deep Learning for enhanced decision-making.

**System Components**

**ESP32 Development Board:** The ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities. It serves as the central control unit for our real-time parking system. The ESP32 is responsible for collecting data from the sensors, processing this data, and providing real-time information to users.

**Ultrasonic Sensors:** Ultrasonic sensors are used to measure the distance between the sensor and a nearby object. In the context of a parking system, these sensors are placed above or beside parking spaces. They detect the presence of vehicles and are a key component in determining whether a parking space is occupied or vacant.

1. **PIR Sensors (Passive Infrared)** PIR sensors detect changes in infrared radiation, such as the heat emitted by a moving vehicle or a person. In our system, PIR sensors are placed in parking areas to sense





### Viranchi Pandya *et al.*,

the presence of vehicles. When a vehicle moves into or out of a parking space, the PIR sensor triggers an event to indicate occupancy status.

2. **Infrared Obstacle Sensors** Infrared obstacle sensors are designed to detect the presence of objects or vehicles in their vicinity. They are often positioned on the ground to sense the presence or absence of a vehicle in a parking space.
3. **LED Indicators** We employ two LEDs, one red and one green, to indicate the occupancy status of parking spaces. The red LED is used to signify that a space is occupied, while the green LED indicates that a space is available for parking.

#### Workflow

1. **Data Collection** The ESP32 reads data from ultrasonic, PIR and infrared sensors continuously.
2. **Data Processing** The ESP32 processes this data combining information from all sensors to determine the occupancy status of each parking space.
3. **LED Indicators** The ESP32 controls the red and the green LEDs to provide real-time visual feedback on parking space availability.
4. **User Access** Users can access this real-time information through various means, such as a dedicated mobile app, a website or digital displays at the parking facility.

#### Benefits

1. **Real-Time Monitoring** The use of IoT sensors and LEDs enable real-time monitoring of parking space occupancy. Users can quickly identify available parking spaces, reducing congestion and wait times.
2. **Data-Driven Insights** The collected data can be used for data analytics and informed decision-making. Parking operators can analyze historical data and implement strategies to optimize space utilization.

#### PROPOSED ARCHITECTURE

A real-time parking management system using IoT technology with the integration of three distinct sensors: ultrasonic, PIR (Passive Infrared) and obstacle avoidance is designed to offer comprehensive parking solutions. This system aims to address the challenges associated with improper parking, enhance user experience and optimize parking space utilization. The architecture of this system involves sensor nodes deployed at various positions within the parking area. Ultrasonic sensors are positioned to measure the distance between vehicles, PIR sensors detect the presence of occupants within vehicles, and obstacle avoidance sensors are placed strategically to prevent collisions and guide drivers while parking. The data collected from these sensors is transmitted to a central IoT gateway or server, which processes the information in real-time. Algorithms are used to analyze this data and determine whether a vehicle is properly parked or not. If a vehicle is found to be improperly parked, the system can trigger notifications to parking attendants or the vehicle owner through a mobile app or SMS, helping to maintain order and compliance within the parking facility. Additionally, the system can provide real-time information to drivers, such as available parking spaces, location guidance, and the overall status of the parking facility, enhancing the user experience. Data analytics can be used to generate insights and reports on parking patterns, usage trends, and potential areas for improvement. By combining ultrasonic, PIR, and obstacle avoidance sensors with IoT technology, this architecture offers a robust and efficient solution for real-time parking management, ensuring that vehicles are parked properly, and the parking facility operates smoothly and safely.

#### RESULTS & CONCLUSION

In conclusion, our research on real-time parking using the Internet of Things (IoT) represents a significant step towards addressing the pressing challenges associated with the rapid increase in vehicle ownership and urbanization. We have introduced an innovative, IoT-based parking management system that leverages advanced sensors, predictive analytics, and user-friendly interfaces to revolutionize the way we manage parking spaces in urban environments. By seamlessly detecting, predicting, and optimizing parking spaces in real time, our system not only enhances the overall parking experience but also contributes to sustainability by reducing fuel





**Viranchi Pandya et al.,**

consumption, congestion, and carbon emissions. It is a solution designed to make urban mobility more efficient and accessible while minimizing the need for human intervention. Moving forward, one can envision this research as a cornerstone for reshaping the future of parking management. We believe that this technology can play a pivotal role in creating smarter, more sustainable, and easily navigable urban environments. The potential for our real-time parking system to transform the way we approach parking management is vast, and we are excited to see its practical applications in our ever- evolving vehicular landscape. In a world where urbanization and vehicle ownership continue to grow, our IoT-based real-time parking system represents a promising path towards a more efficient, sustainable, and user- friendly urban future.

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<p><b>Fig. 1. IOT system architecture for real time parking system</b></p>	<p><b>Fig. 2. Circuit Diagram of Iot component of Real Time Parking System</b></p>																																																							
	<table border="1"> <thead> <tr> <th>Picture no</th> <th>Parking Lot Free/Not</th> <th>Detected by Ultrasonic Sensor</th> <th>Detected by Infrared Obstacle Sensor</th> <th>Detected by PIR sensor</th> </tr> </thead> <tbody> <tr><td>1</td><td>Free</td><td>No</td><td>No</td><td>No</td></tr> <tr><td>2</td><td>Parked</td><td>Yes</td><td>No</td><td>No</td></tr> <tr><td>3</td><td>Free</td><td>No</td><td>No</td><td>No</td></tr> <tr><td>4</td><td>Parked</td><td>No</td><td>Yes</td><td>No</td></tr> <tr><td>5</td><td>Free</td><td>No</td><td>No</td><td>No</td></tr> <tr><td>6</td><td>Parked</td><td>No</td><td>No</td><td>Yes</td></tr> <tr><td>7</td><td>Free</td><td>No</td><td>No</td><td>No</td></tr> <tr><td>8</td><td>Parked</td><td>No</td><td>Yes</td><td>No</td></tr> <tr><td>9</td><td>Parked</td><td>Yes</td><td>No</td><td>Yes</td></tr> <tr><td>10</td><td>Parked</td><td>Yes</td><td>Yes</td><td>Yes</td></tr> </tbody> </table>	Picture no	Parking Lot Free/Not	Detected by Ultrasonic Sensor	Detected by Infrared Obstacle Sensor	Detected by PIR sensor	1	Free	No	No	No	2	Parked	Yes	No	No	3	Free	No	No	No	4	Parked	No	Yes	No	5	Free	No	No	No	6	Parked	No	No	Yes	7	Free	No	No	No	8	Parked	No	Yes	No	9	Parked	Yes	No	Yes	10	Parked	Yes	Yes	Yes
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<p><b>Fig. 3 Results</b></p>	<p><b>Fig. 4. Summary Table of above 10 images depending on which sensor detects the car covering all the cases</b></p>																																																							







## Deep learning approaches for image restoration Comprehensive Survey

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### ABSTRACT

This review offers a thorough analysis of the literature on the use of deep learning methods in image restoration. Deep neural network capabilities have spurred substantial breakthroughs in image restoration, which includes tasks like dehazing, denoising, super resolution, and deblurring. Focusing on the development of Convolutional Neural Networks (CNNs), Generative Adversarial Networks (GANs), and other deep learning architectures, the paper methodically looks at significant contributions, techniques, and trends across a range of picture restoration problems. To get state-of-the-art outcomes, we explore the subtleties of network designs, training approaches, and data augmentation methodologies. We explore the intricacies of network architectures, training methodologies, and data augmentation tactics that have been essential in attaining cutting-edge outcomes. In addition, this literature analysis opens the door for further research by shedding light on the difficulties and unanswered problems in the field. This publication provides a thorough resource for scholars, practitioners, and hobbyists interested in deep learning-based picture restoration, by combining results from several investigations.

**Keywords:** Deep Learning, Deblurring, Neural Network Architectures, Image Restoration, Training Strategies, State-of-the-Art, Image Quality Enhancement





**Rikita Chokshi and Sudhir Vegad**

## INTRODUCTION

The quality of visual content is crucial in an era where digital imaging rules. The need for clear, high-quality photographs goes beyond personal photography and affects vital fields including surveillance, medical imaging, remote sensing, and artistic expression. But several degradations, such as noise, blur, artefacts, and low-resolution problems, often tarnish the quality of images. Image restoration has long been a focus of study and invention, with the goal of improving and recovering image quality. With the advent of deep learning techniques, the field of image restoration has experienced a paradigm shift in recent years. Significant progress in image restoration has been made possible by the development of convolutional neural networks (CNNs) and the spread of deep neural architectures. In addition to achieving state-of-the-art performance, deep learning has addressed a wide range of picture degradation concerns by adding a new degree of adaptation and generalization to the area. The goal of this literature review study is to present a thorough examination of the field of deep learning-based picture restoration approaches. This review's main goal is to clarify the advancements, difficulties, and applications in this emerging topic. We aim to provide a thorough overview of the state-of-the-art in image restoration by deep learning by compiling and analysing a wide range of academic contributions. This will help practitioners and researchers alike understand the fundamental ideas and most current advancements in the field. This literature review is organised in a way that walks readers through the most important facets of picture restoration. We start by giving a quick overview of the development of picture restoration techniques throughout history, emphasising the shift from conventional approaches to the present deep learning period. We then explore the basic ideas of deep learning, with a focus on the training methodologies and architectural elements that support image restoration. In addition, we provide an in-depth analysis of popular deep learning models and algorithms for image restoration tasks, including super-resolution, deblurring, denoising, and artefact removal. We also talk about the difficulties and issues surrounding practical applications, as well as the moral and societal ramifications of picture restoration. Ultimately, this review is intended to serve as a valuable resource for researchers, engineers, and enthusiasts navigating the dynamic terrain of image restoration using deep learning. It is our aspiration that the synthesis of knowledge contained herein will facilitate a deeper understanding of the potentials and limitations of current methodologies, spurring further innovations and improvements in the quest for image perfection.

## LITERATURE SURVEY

### Image deblurring techniques classification

There are two primary categories into which Image deblurring techniques can be classified: those that rely on an understanding of the point spread function, or  $H(u,v)$ . Figure 4 illustrates (i) Non-blind image deconvolution and (ii) blind image deconvolution. The first type's blurred image and point spread function are well known to us. Regarding PSF and blurry images in the second category, we don't have any information. As a result, it is used when we are unfamiliar with PSF, leading to blur and deterioration. [4] Since most practical contexts prevent knowing the PSF, blind deconvolution is most helpful in real-world scenarios. For instance, estimating the scene in astronomy and remote sensing applications is extremely difficult and complex, something we have never seen before.

### Review

P. Patil et al. have shown a comparison of categories of deconvolution technique and the flow of those techniques [1]. R. Chokshi et al. has proposed a blind deconvolution technique for image restoration by identifying and estimating blur. They also have proposed an approach for the same [2]. Pooja Satish et al have presented comprehensive survey of the different Image deblurring techniques and analysed the strengths and weaknesses of different image deblurring algorithms [3]. Himanshu Joshi et al have presented the literature study about the work done in the field of image restoration and also discusses some techniques of image restoration with their merits and demerits [4]. S. Motohashi et al. have proposed an innovative approach for PSF estimation for blind image deconvolution utilizing total variation regularization, an impact filter and the gradient reliability map [5]. K. Zhang



**Rikita Chokshi and Sudhir Vegad**

at al have presented a taxonomy of methods using convolutional neural networks (CNN) based on architecture, loss function, and application, offering a detailed review and comparison. In addition, they have also discussed some domain-specific deblurring applications including face images, text, and stereo image pairs. We conclude by discussing key challenges and future research directions [6]. S. Waqas et al have proposed Restoration Transformer (Restormer), that achieves several image restoration tasks, including image deraining, single-image motion deblurring, defocus deblurring (single-image and dual-pixel data), and image denoising (Gaussian grayscale/color denoising, and real image denoising) [7]. D. Singh et al have proposed a unified framework for restoration process by enhancement and more quantified deblurred images with the help of Genetic Algorithm [8]. Gustav Bredell et al have shown an unsupervised blind image deconvolution method by guiding optimization of DIP with Wiener-deconvolution to obtain more stable and enhanced deblurring performance [9]. Jaihyun Koh et al have shown existing deep deblurring methods for both blind and non-blind deconvolution [10]. Dong et al have shown how model is trained in an end-to-end manner and evaluated on scenarios with both simulated and real-world image blur [11]. Zhang et al have implemented Non Homogeneous Dehazing of images (restoration of rich details in hazy image) [12]. Nah et al have proposed a multi-scale convolutional neural network that restores sharp images in an end-to-end manner where blur is caused by various sources [13]. Tao et al have presented a Scale-recurrent Network (SRN-DeblurNet) for single image deblurring, the “coarse-to-fine” scheme [14]. Kupyn et al have proposed generative adversarial network (GAN) for single image motion deblurring, named DeblurGAN-V2 from existing one [15]. Zhang et al have presented the approach of how to train a set of fast and effective CNN (convolutional neural network) denoisers and integrate them into model-based optimization method to solve inverse problems [16].

**COMPARISON OF IMAGE RESTORATION TECHNIQUES USING DEEP LEARNING MODELS FOR IMAGE RESTORATION****AREAS OF DEEP NETWORKS FOR IMAGE RESTORATION****CHALLENGES**

1. Lack of Blur Information (Blind Deblurring): In many real-world scenarios, the exact blur kernel (the mathematical description of the blur) is unknown. This is known as blind deblurring, and it makes the deblurring task significantly more challenging. Addressing this challenge often requires advanced algorithms and prior knowledge about the image or the blur.
2. Motion and Spatially Varying Blur: In some cases, the blur in an image can be caused by motion or other factors that vary spatially. Models must be able to handle spatially varying blur to accurately restore the image.
3. Noise and Artifacts: Deblurring can amplify noise and introduce artifacts in the restored image, particularly when aggressive deblurring is applied. Balancing sharpness and noise reduction is a critical consideration.
4. Computational Complexity: Some image deblurring algorithms and models can be computationally intensive, making real-time or on-device processing challenging. Efficient models and optimization techniques are needed for practical applications.
5. Amount of Available Data: Deep learning models for image deblurring often require a large amount of training data to generalize well. Collecting or creating diverse datasets with different types of blur can be a time-consuming and resource-intensive task.
6. Generalization: Models need to be capable of generalizing to a wide range of blur types and levels, including those that may not be present in the training data. Achieving good generalization is a significant challenge.
7. Blur Estimation: In blind deblurring, accurately estimating the blur kernel is a crucial step. Errors in blur estimation can lead to suboptimal deblurring results.
8. Real-World Conditions: Images captured in real-world conditions may have multiple sources of degradation, such as motion blur, noise, and low lighting. Dealing with multiple degradation factors simultaneously can be challenging.



**Rikita Chokshi and Sudhir Vegad**

9. Evaluation Metrics: Choosing appropriate evaluation metrics for image deblurring is crucial. Common metrics include peak signal-to-noise ratio (PSNR) and structural similarity index (SSIM), but they may not always reflect the perceived quality of the deblurred image accurately.

**APPLICATIONS****FUTURE DIRECTIONS**

1. There is still a difference between these synthetic images and real-world hazy photos.
2. The majority of deep learning based approaches require paired fuzzy and clear images for training, where the blurry inputs are artificially synthesized.
3. In addition to blur artefacts, quantization, sensor noise, and other issues like low resolution can also cause real-world photographs to be distorted.
4. There are no universal techniques for retrieving crisp text or facial photos (for all types of items). [6]
5. Addressing the challenge of blind image restoration, where the specific degradation characteristics are unknown.
6. Deep learning models that can adapt to various types of degradation needs to be considered.

**PERFORMANCE MEASURES: IMAGE QUALITY METRICS**

For the purpose of objectively testing the performance of image restoration algorithms and to measure the quality of resultant images three quality metrics can be used: MSE (Mean Square Error), PSNR (Peak Signal to Noise Ratio) and SSIM (Structural Similarity Index) [8].

**CONCLUSION**

This comprehensive literature review has provided a panoramic overview of the strides made in the domain of image restoration through the lens of deep learning approaches. From an exploration of Convolutional Neural Networks (CNNs) to the nuanced complexities of Generative Adversarial Networks (GANs), our analysis has underscored the transformative impact of deep learning architectures on various image restoration tasks, including deblurring, denoising, dehazing, and super resolution. The survey revealed a dynamic landscape characterized by continual innovation in network designs, training methodologies, and data augmentation techniques. State-of-the-art results demonstrate the efficacy of deep learning models in capturing intricate features, mitigating noise, and restoring visual fidelity across diverse applications. This review also sheds light on existing challenges, including interpretability, generalization to diverse datasets, and the need for more standardized evaluation metrics. This literature review serves as a roadmap for researchers, practitioners, and enthusiasts navigating the expansive terrain of deep learning for image restoration. By distilling key findings, identifying current challenges, and envisioning future directions, this work aims to contribute to the continued evolution and refinement of cutting-edge methodologies in this dynamic and rapidly advancing field.

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**Rikita Chokshi and Sudhir Vegad**

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**TABLE I.IMAGE RESTORATION TECHNIQUES COMPARISION**

Image restoration techniques using Deep Learning Models	Merits	Demerits
Convolutional Neural Networks(CNNs)	CNNs are highly effectivein capturing local andglobal features in images. They can learn hierarchicalrepresentations, which isuseful for tasks like super-resolution and denoising.	Limited receptive fields of convolutional layers may struggle with capturing long-range dependencies.
Auto encoders	Auto encoders can learn compact representations of input data, making them useful for tasks likedenoising. They can be trained in an unsupervised manner.	Limited in capturing complex, non-linearrelationships in data compared to other architectures.
Generative Adversarial Networks (GANs)	GANs can generaterealistic high-resolution images and are effective for tasks like super-resolution. They introduce a competitive training process, improving the quality of generated images.	Training GANs can be challenging andrequires carefulbalancing to avoid mode collapse.
Residual Networks	Residual connections help in training	Increased modelcomplexity





**Rikita Chokshi and Sudhir Vegad**

<b>(ResNets)</b>	deeper networks without vanishing gradient problems. Suitable for tasks where preserving fine details is crucial, such as image denoising.	may lead to overfitting on smaller datasets.
<b>U-Net Architecture</b>	U-Net is widely used for tasks like image segmentation and restoration. The architecture includes skip connections, allowing the model to capture both low-level and high-level features.	May struggle with handling large receptive fields efficiently.
<b>Wavelet Transform-based Networks</b>	Utilizes wavelet transform to capture multi-resolution information. Effective for handling different scales of details in an image.	May introduce additional computational complexity.
<b>Attention Mechanisms</b>	Attention mechanisms allow models to focus on relevant parts of the input, enhancing performance in tasks like image denoising.	Increased computational cost due to the need to compute attention weights.

**TABLE II. AREAS OF DEEP NETWORKS FOR IMAGE RESTORATION**

Area	Description	Deep learning approach
<b>Image Restoration</b>	Image restoration involves enhancing the quality of an image by reducing artifacts or imperfections introduced during the acquisition process.	Convolutional Neural Networks (CNNs) are commonly used for image restoration tasks, capturing both local and global features for improved quality.
<b>Image Deblurring</b>	Image deblurring aims to remove blurriness caused by motion, defocus, or other factors, resulting in a sharper and clearer image.	Deblurring models often use architectures like CNNs, Residual Networks (ResNets), or GANs to recover high-frequency details.
<b>Image Denoising</b>	Image denoising focuses on reducing noise in images, enhancing their clarity and removing unwanted artifacts.	Auto encoders, CNNs, and U-Net architectures are popular choices for image denoising tasks, effectively learning noise patterns.
<b>Image Dehazing</b>	Image dehazing aims to improve visibility in hazy or foggy images by removing atmospheric scattering effects.	CNNs and GANs are employed to learn the underlying haze-free information, restoring clear details in the image.
<b>Image Super Resolution</b>	Image super resolution involves increasing the resolution of an image, generating a higher-quality version from a lower-resolution input.	Super-resolution tasks often use CNNs, GANs, or architectures like SRCNN (Super-Resolution Convolutional Neural Network) for upscaling and enhancing details.





**Rikita Chokshi and Sudhir Vegad**

<b>Image Quality Assessment</b>	Image quality assessment focuses on evaluating the perceptual quality of images, often used to measure the success of restoration algorithms.	Deep neural networks are trained to predict image quality scores, providing a more objective and automated assessment compared to traditional metrics.
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**TABLE III. IMAGE QUALITY METRICS**

Metric	Equation	Better Quality Indicator
MSE	$MSE = \frac{1}{MN} \sum_{n=0}^M \sum_{m=1}^N [g^{\wedge}(n,m) - g(n,m)]^2$	Low
PSNR	$10 \log_{10}(\text{peakval}^2 / \text{MSE})$	High
SSIM	$SSIM(x, y) = l(x, y) \cdot c(x, y) \cdot s(x, y)$	High

<p>Different Types of Blur → Objective → PSF</p>	<p>Astronomy Medical Remote Microscopy</p>
<b>Fig 1 Flow of image Restoration</b>	<b>Fig 2 Applications of image Restoration</b>







## Process Automation in Women-Led Msme Units :A Case Study of Small-Scale Industries in Uttarsanda

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### ABSTRACT

With the corporate world going through tough competition, business units need to constantly innovate and upgrade using the latest technology. This goes well not only with large-scale and medium-scale enterprises, but also those small-scale as well as micro-enterprises and cottage industries, mostly run by women entrepreneurs. While these women entrepreneurs are playing a vital role in the development of the Indian economy, they need to ensure they are ready to be the game-changers by moving with the time and are implementing the best practices in their business. Such technologies help in ease of production process, improvement and standarization of quality as well as wastage of resources. Also, technology can also be used for identifying newer markets and the means to reach there. With the world that has now become a global village, technology has also become the backbone of supply chain management. the Hence, the more use of technology, the higher the benefits for the entrepreneur.

**Keywords:** MSME, Small Scale Industries, Women Entrepreneurs, Entrepreneurship, Technology in women enterprises

### INTRODUCTION

Entrepreneurship has been one of the oldest professions in the world. According to the Global Entrepreneurship Report 2023 Global Report, the number of entrepreneurs in the world is approximately 594 Million, which constitutes 7.4% of the overall global population. The number of women entrepreneurs worldwide is approximately 252 Million, which accounts for 43% of the total entrepreneurs. India leads all other countries with approximately 105 Million entrepreneurs, out of which around 15 Million are females. Therefore the proportion of female entrepreneurs in India is about 14%, which is very less as compared to the global rate. Most of the large-scale and medium-scale enterprises in India are owned by men, and the proportion of female entrepreneurship is slightly higher in Small-scale and

70110



**Aadarsh Pillai and Rina Dave**

Micro-enterprises, which is about 20%. These female entrepreneurs provide employment to about 25 Million persons in India. Female entrepreneurship is also higher in rural areas, as compared to the urban parts of India. With a major chunk of these units belonging to the Micro-units and Cottage Industries mostly operating from home or from unorganized set up, use of technology and process automation remains a challenge. This is also triggered by the low literacy level of such female entrepreneurs in the rural areas. With the market continuously evolving amidst increasing competition, and customers demanding better quality products, business units need to evolve by embracing technology not only to improve their production process, but also to innovate and develop newer products.

**REVIEW OF LITERATURE**

In [1] **Gulia, Suman (2022)** has done a detailed study on the problems faced by Indian female entrepreneurs and has also enlisted the various schemes designed by the Government of India, to provide financial assistance to female entrepreneurs. In [2] **Aggrawal, Artee; Carick, Jon; Kennedy, Jeffrey and Fernandez, Giovanni (2022)** have conducted an exploratory study to understand the plight of women entrepreneurs in India, having done indepth interviews of ten women entrepreneurs to come to their conclusions. In [3] **Saraswat, Ritwik and Lathabahvan, Remya (2020)** have conducted an extensive study on the factors affecting entrepreneurship amongst females in India, and to understand the mindset of the people of various strata of the society, regarding female entrepreneurship. In [4] **Arya, Sadhana; Panda, Shiba and Kaur, Gurveen (2017)** have elaborated on the status of female entrepreneurs in India and they have also done a study to understand the reasons behind females taking up the role of entrepreneurs in the country. In [5] **Rajalakshmi, A. (2014)** has highlighted the role of women entrepreneurs in the development of the Indian economy, and felt the need to provide more resources to the female entrepreneurs so that they can take their businesses to greater heights.

**OBJECTIVES**

This study focuses on the women-led micro-enterprises and cottage industries thriving in Uttarsanda area of Kheda district in Gujarat :-

1. To understand the level of technology and automation used by them in their business set-up
2. To identify the challenges they face on ground, to adopt new technologies.
3. To ascertain whether the production capacity is being fully utilized and what can be done to overcome any underutilization.

**RESEARCH METHODOLOGY**

In order to have an indepth knowledge about the role of women entrepreneurs, and the overall common challenges faced by them, secondary data has been used. This is mainly through study of previous research papers on this topic, as well as information released by the Government of India. As regards to the on-ground performance of the female entrepreneurs in Uttarsanda, the authors have conducted personal interviews of 5 of the top entrepreneurs of that area. Since there is no analysis of data involved in this study, no statistical tools have been used in this context

**STUDY FINDINGS**

Uttarsanda village lies under Nadiad Taluka in Kheda District of Gujarat. As per the Census conducted by the Government of India in 2011, the population of Uttarsanda was 10,616 and it is estimated that the present population is upto 12,950. The literacy rate of this village was 90% as per the 2011 census, which is much better than the state literacy rate of 78% and the national literacy rate of 74%. Uttarsanda is also known for the various varieties of Papads being manufactured in about 35 micro-enterprises that have been operational in this area, most of them have been around for more than 30 years. The main speciality of these units is that most of them are run by women entrepreneurs, and it also employs a nearly 95% female workers in the entire production process. It is estimated that the total turnover of these units is Rs. 70 crores per annum. 80% of the households in this village have their relatives



**Aadarsh Pillai and Rina Dave**

staying abroad, mainly in the USA and UK, and these NRIs/PIOs have made it a point to carry back a fair quantity of these local papads, whenever they visit India. It is also estimated that 20% of the products manufactured here are exported. However, with all these fanfares, where does Uttarsanda stand as compared to the overall market size in the country? As per the Forst and Sullivan Analysis, the papad market in India was of Rs. 74 Billion in the year 2021, out of which 32% was catered by the organized sector whereas remaining 68% by the unorganized sector. The papad market is estimated to grow at a CAGR of 7.6%, which means reaching a market size of Rs. 100 Billion by the year 2023. Therefore the total market share of these units in Uttarsanda is roughly 1%. There is an ample scope of expanding the market share by concerted efforts. Detailed discussion and probing during the interviews of the entrepreneurs (including the units that are operational now, as well as those who operate in seasons) have come out with some interesting results.

The ground reality in Uttarsanda is that only 7 units operate throughout the year. Remaining 28 units operate seasonally, mostly during the Diwali season when they consider the demand to be high. Therefore 80% of the units remain shut for most part of the year. As for these 7 units which operate throughout the year, there are some similarities in them :-

- 1) They have semi-automatic papad making machines of various capacities installed.
- 2) They have also expanded their product range by introducing various flavours and types of papads and other snacks.
- 3) They have their websites through which they are also catering to their online orders as well as export enquiries.
- 4) They use modern marketing techniques in order to promote their products through social media. Therefore they have succeeded in promoting their brand.

None of these units have any dedicated R&D activities, therefore the chances of product innovation, new product development, etc. is very bleak.

With such a huge market lying open, the main reasons why other units are still operating only during seasons, thereby causing huge capacity underutilization, are :-

- 1) Sticking to the some old conventional product range
- 2) Not willing to upgrade their production process from manual to automatic or semi-automatic
- 3) Lack of proper understanding of the overall market size within the country
- 4) Reluctance in using modern marketing techniques such as online marketing, social media marketing, etc
- 5) Considering exports as a cumbersome process and an activity of high risk.
- 6) Lack of a formal association or group that could keep them in loop with the market trends as well as other factors.

None of these entrepreneurs were in favour of creating an association or society, as they believed in operating independently. And none of them cited financial difficulties as a reason for their underperformance.

Therefore the willingness to share knowledge or to create avenues of expansion through cooperation, was totally absent.

## CONCLUSION

India has been a very good market for processed food and more players are now entering the market, as these organized sector units invest in new technologies, automation, quality enhancements, etc. Papad and similar snacks have been a regular part of the Indian food habit. With such a huge market for this item, and such big scope for the organized sector to play within, the overall performance of these women-led enterprises in Uttarsanda, is not upto the mark. The need of the hour for them is to embrace technology to automate their production process, focus on R&D of newer products and variants, as well as tap the market using proper technological tools to promote their



**Aadarsh Pillai and Rina Dave**

products. Sticking to conventional products and conventional production process would not be helpful in the long run.

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## Coal Mining Safety using Zig Bee

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### ABSTRACT

In the domain of coal mining safety, this project implements a wireless gas monitoring system. By integrating an Arduino Uno with a gas sensor, DHT-11 sensor and utilizing XBee S2C modules for data transmission, we achieve real-time gas level and temperature monitoring. The collected data is wirelessly transmitted to another Arduino Uno, which is connected to a serial monitor, facilitating swift responses to hazardous conditions. This project caters to the increasing need for improved safety measures in coal mining operations by harnessing advanced technology and real-time data monitoring. Our system provides a solution to mitigate gas-related hazards, monitor environmental conditions, and safeguard the well-being of miners. This contribution aligns with the broader objective of enhancing safety protocols within the mining industry.

**Keywords:** Internet of Things, Sensors, Automation, Microcontrollers, Smart systems

## INTRODUCTION

The coal mining industry is a pivotal source of fuel for industrial processes and power production, playing a crucial role in the global energy sector. However, this industry is not without its hazards, with one of the most significant being the presence of explosive and toxic gases, including methane, carbon monoxide, and hydrogen sulfide, which can accumulate in underground mines. These gases are not only flammable but also pose significant risks to human health, potentially leading to respiratory issues and even fatalities if not effectively monitored and controlled. Moreover, the environmental conditions within mines, including temperature and humidity, can have implications for both worker safety and equipment performance. To tackle these challenges head-on, our project focuses on implementing a comprehensive wireless monitoring system that addresses both gas-related and environmental hazards in coal mining. By utilizing the capabilities of the Arduino Uno, DHT11 temperature and humidity sensor, and XBee S2C modules, we have developed a real-time monitoring solution. This system can



**Viranchi Pandya et al.,**

promptly identify hazardous gas concentrations and monitor critical environmental conditions, enabling swift responses to potential gas-related incidents and environmental fluctuations. Our project aims to significantly contribute to the advancement of safety protocols in coal mining operations, equipping miners with more effective tools to manage the challenges posed by hazardous gases and environmental conditions.

## METHODOLOGY

### Components

**MQ-6 Gas Sensor** The MQ-6 sensor plays a pivotal role in detecting methane gas in coal mines. It offers continuous monitoring of gas concentration levels and issues warnings when they surpass predefined safety thresholds. This data is instrumental in adjusting airflow to maintain safe gas levels

**DHT-11 Sensor** The DHT11 sensor provides continuous monitoring of temperature and humidity levels, which is indispensable for ensuring safety and productivity in mining operations. Fluctuations in these parameters can affect miner well-being, safety, and equipment performance. When temperature or humidity levels deviate from predetermined safety thresholds, warnings are generated to sustain a safe and comfortable working environment.

**Arduino UNO boards** Two Arduino Uno boards are employed in the project. The first board, linked to the gas sensor and DHT11 sensor, collects sensor data and transmits it, while the second board, connected to the serial monitor, is responsible for receiving and processing the data.

**XBee S2C modules** XBee S2C modules enable wireless communication between the gas sensor, DHT11 sensor, and the serial monitor Arduino Uno. For wireless M2M and IoT networks that are low-cost and low-power, Zigbee is a wireless technology that is based on standards. In comparison to a WiFi network, ZigBee provides significantly lower data rates and use a mesh networking protocol to eliminate hub devices and build a self-healing architecture. Zigbee is a standard protocol with a modest data rate and consumes less power.

**XCTU** Before integrating the XBee modules into our system, they require proper configuration. Key parameters, such as baud rate, channel, PAN ID, and addressing modes, need to be harmonized. We accomplish this through software tools like XCTU (Xbee Configuration and Test Utility) to ensure compatibility and effective data exchange.

**Serial Monitor** The Serial Monitor is a crucial component, primarily responsible for real-time monitoring of gas concentration levels. It triggers safety alerts in hazardous conditions, logs historical data, and provides an accessible interface for operators and miners, enhancing safety in coal mining operations.

### System Architecture and Integration

1. The gas sensor, DHT11 sensor and Arduino UNO continually collect gas and environmental data, which is transmitted to the TX module of the XBee S2C. The RX module, connected to the serial monitor Arduino Uno, receives and processes this data.
2. The Serial Monitor, linked to the serial monitor Arduino Uno, is vital for real-time monitoring of gas concentration levels and environmental conditions. It is equipped to trigger safety alerts in hazardous conditions, log historical data, and provide an accessible interface for operators and miners, thus enhancing safety in coal mining operations.

### Flowchart

The flowchart outlines the data flow from sensor acquisition to transmission, reception, processing, safety monitoring.







**Viranchi Pandya et al.,**

**RESULTS**

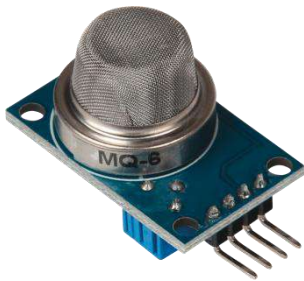
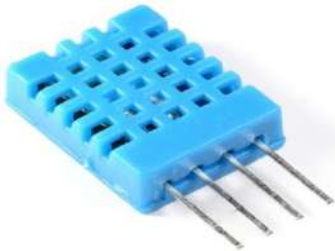
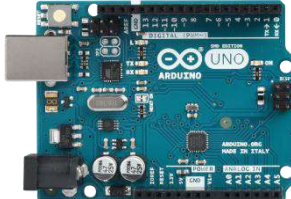

The results obtained after implementing the system are shown in the figures below.

**CONCLUSION**

Our coal mining safety project signifies progress in improving safety measures. Through the integration of gas sensors, environmental monitors, and wireless communication, the system enables continuous monitoring of gas levels and environmental conditions. Timely alerts facilitate swift responses, including ventilation adjustments, to mitigate potential hazards. This project serves as a cornerstone for sustainable and secure mining practices, aligning with stringent regulatory standards that govern the industry.

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<p><b>Fig. 1. MQ-6 Gas Sensor</b></p>	<p><b>Fig. 2. DHT-11 Sensor</b></p>
	
<p><b>Fig. 3. Arduino UNO</b></p>	<p><b>Fig. 4. Zigbee Module</b></p>





Viranchi Pandya et al.,

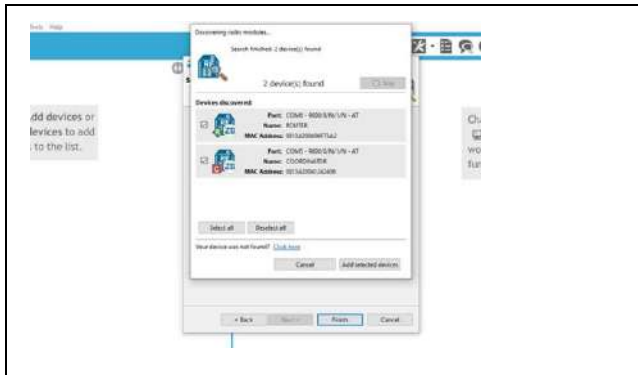


Fig. 5. XCTU Configuration



Fig. 6. Router Zigbee Details



Fig. 7. Coordinator Zigbee Details

Parameters	MQ-6 Sensor	DHT-11	Zigbee Module
Use	Gas Concentration Sensing	Temperature and humidity sensing	Transceiver
Operating Voltage	5V	3.3 to 5.5V	2.1- 3.6 V
Operating Current	150-160mA	0.5 mA measuring, 60uA standby	45mA
Output Voltage	0.2 - 4.8V	-	-
Operating Temperature Range	-10 to 50 degree celsius	Temperature 0°C to 50°C, Humidity 20% to 90%	-40 to 85 degree celsius
Output/Sensing Range	200ppm to 10000ppm	-	4000ft.

Fig. 8. Component Specifications



Fig. 9. Hardware Setup

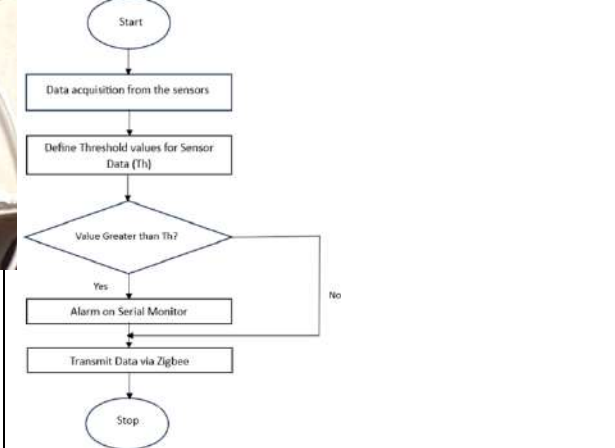


Fig. 10. Flowchart

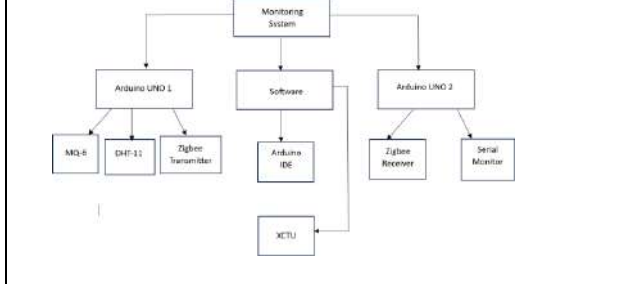


Fig. 11. Block Diagram of the System

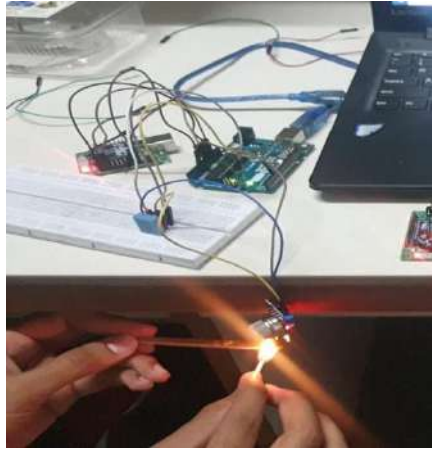
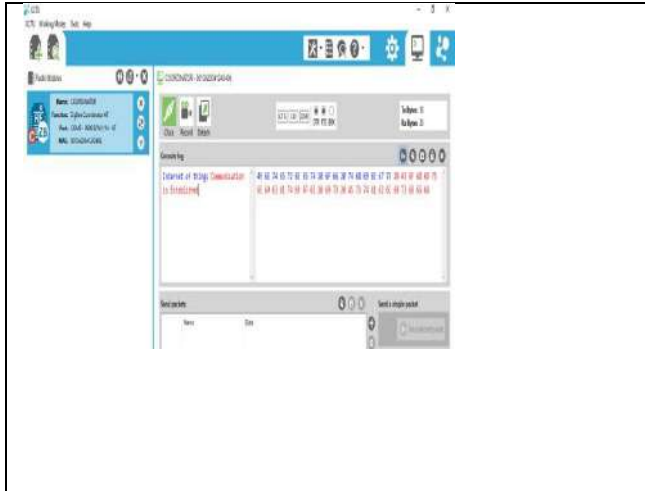


Fig. 12. Communication Established - Router End



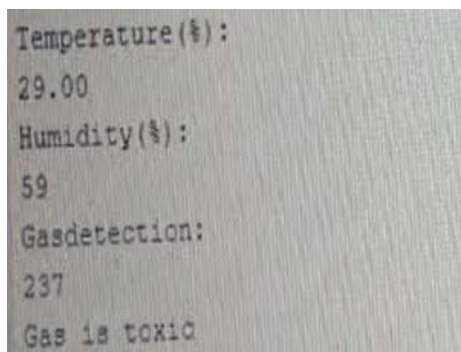
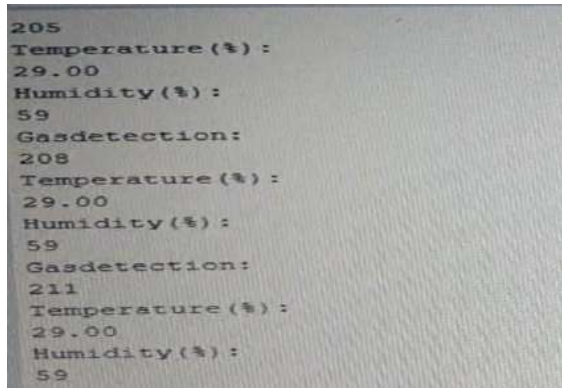


**Viranchi Pandya et al.,**



**Fig. 13. Communication Established - Coordinator End**

**Fig. 14. Live Sensor Monitoring**



**Fig. 15. Serial Monitor Output when Levels Normal**

**Fig. 16. Toxicity Alarm at Serial Monitor**





## Evaluation of Strength and Comparative Study on Silica Fume

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### ABSTRACT

Since advent of civilization various types of cementitious materials have been used for construction practices. The arrival of Ordinary Portl and Cement (OPC) changed the construction activities completely. However, because of several draw backs associated with properties of cement and manufactured building materials such as OPC as well as the cost factor attempts one mode to utilize other materials for economical constructions and improved mortar and concrete characteristics. About 8-10% of CO<sub>2</sub> emissions are generated from concrete production and transportation. Global warming gas is released when the raw material of cement, limestone and clay is crushed and heated in a furnace at high temperature. Onset on cement produces approximately one ton of carbon dioxide in atmosphere Also, several waste materials are generated in huge quantities by different industrial activities. Now attempts were made to utilize these waste materials or industrial byproducts in construction activities to solve the environmental pollution problems, and safer and economical construction. Silica fume is one such industrial by product which is being used and experimented upon to obtain a stronger and durable concrete. It is one of the pozzolanas having very large surface area which results in better and uniform utilization of calcium hydroxide released during hydration of OPC. Also, because of its very fine size it act as filler material between the cement gel grains. The use of silica fume as a mineral admixture to produce high strength high performance concretes is gaining importance in recent years. The aim of the study was to investigate the effects of binder systems containing different levels of silica fume on fresh and harden properties of concrete. The work was focused on concrete mixes of grade M-25 having a fixed water cement ratio of 0.45. The percentage of silica fume replaced with cement was: 5%, 10%, and 15%.At 10% replacement of cement with silica fume, it gave the highest compressive strength. And workability was reduced at high silica percentage.





Vishal Nihalani et al.,

**Keywords:** Compressive strength, work ability, global warming, Silica fume, carbone mission, w/cratio.

## INTRODUCTION

Ferrosilicon and silicon metal are the primary sources of the industrial byproduct known as silica fume. It readily reacts with the calcium hydroxide produced during the hydration of Portland cement. The pore structure of the concrete is improved and its mechanical strength is increased when silica fume is added. As a reactive pozzolan, silica fume has a very high specific surface. Compared to the pozzolanic materials, silica fume is typically used in comparatively small quantities. It is problematic that it disperses uniformly in concrete. From a mineral admixture point of view, silica fume is a very promising option for making high- to ultra-high-strength concrete, but mixing it properly is essential. This study identifies the advantages of using silica fume to partially replace cement in concrete. The purpose of the current experiment is to compare the compressive strengths of conventional concrete and concrete made with silica fume. By substituting silica fume for cement at varying percentages, a suitable percentage of silica fume was identified, and the strength parameters were compared to those of conventional concrete.

## MATERIALS

The materials used for this Study are as follows:

**Cement:** Ordinary Portland cement of grade 53 was used for experimental work. The OPC used was grey in colour and was free of hard lumps.

**Fine aggregates:** stone Crushed S and was used as fine aggregate. As per IS-383(2016)

**Course aggregates:** Locally available coarse aggregates having the maximum size of 20 mm was used. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS:2386 (1963)(Part 3).

**Water:** tap water is used for this work.

**Silica fume:** Silica fume used was white in colour and was very finely divided residue resulting from the manufacture of silicon or ferro-silicon alloys that is passed from the furnace by the exhaust gases. It was of 92D. It normally comes in three forms of powder, condensed and in slurry form. Silica fume is often used in the creation of high-strength concrete with or without the addition of fly as horslag. Silica fume generally has a high surface area and a low density and consist of very finely divided particles that are approximately 100 times smaller than the normal cement particle. It offers reactive pozzolanic activity and is very effective due to its high fineness and silica content. Typical physical prosperities of silica fume used for the experimental works is given below in Table.

Property	Value
Particle size	< 1 um
Bulk density as produced	130 – 430 kg/m <sup>3</sup>
Slurry	1320 – 1440 kg/m <sup>3</sup>
Densified	480 – 720 kg/m <sup>3</sup>
Specific gravity	2.22
Surface area	13000 – 30000 kg/m <sup>3</sup>

## MIX DESIGN PROPERTIES

The percentage of silica fume used was 5%, 10%, 15%. Water binder ratio was kept constant at 0.45 and the grade of concrete was M-25. The ratio of mix proportion for all cubes with different proportion were.





## Vishal Nihalani et al.,

Material	Quantity, 1m <sup>3</sup> gm	Prop. By Weight
Cement	395.75	1
Fine Aggregate	692	1.75
Coarse Aggregate	1151.75	2.91
Water Content	186	0.45

Mix design for conventional concrete.

Material	Quantity, 1m <sup>3</sup> gm	Prop. By Weight
Cement	373	1
Silica Fume	25	--
Fine Aggregate	704	1.88
Coarse Aggregate	1171	3.14
Water Content	168	0.45

Mix design for 5% silica fume replacement with cement

Material	Quantity, 1m <sup>3</sup> gm	Prop. By Weight
Cement	356.5	1
Silica Fume	40 gm	--
Fine Aggregate	712	1.99
Coarse Aggregate	1184	3.32
Water Content	160	0.45

Mix design for 10% silica fume replacement with cement

Material	Quantity, 1m <sup>3</sup> gm	Prop. By Weight
Cement	335	1
Silica Fume	60	--
Fine Aggregate	717	2.14
Coarse Aggregate	1193	3.56
Water Content	150	0.45

Mix design for 15% silica fume replacement with cement

**CASTING AND CURING**

The entire test specimen was properly cleaned and oiled prior to casting. Before being cast, these were securely fastened to the right dimensions. Every precaution was taken to ensure that there were no remaining gaps from which slurry could leak. During the casting, mixing, and batching processes, careful procedure was followed. With an accuracy of 0.5 grams, the coarse and fine aggregates were weighed first. The concrete mixture was mixed by hand and by machine to prepare it. On the platform that didn't absorb water, the coarse and fine aggregates were thoroughly mixed together. After that, water was carefully added to ensure that no water was lost during mixing. The cement was incorporated into this blend. These were combined to produce a uniform color. After that, water







Vishal Nihalani *et al.*,

was carefully added to ensure that no water was lost during mixing. Six cubes (150 x 150 x 150mm) with compressive strengths of 7 and 28 days were made for each mix.

## RESULT AND DISCUSSION

### Fresh concrete properties

For the slump cone test, the properties of fresh concrete for various mix types were investigated. And the end result was a real slump.

We observed true slump at 5%, 10%, and 15%, respectively, which is unworkable and incompatible with jacketing and other repair methods.

### Hardened concrete properties

A hardened property was studied for test such as compressive strength, for 7 and 28 days. The cube containing various proportions of silica fume was prepared and cured for seven days in order to study the effect on compressive strength when cement is replaced by silica fume in concrete. The conclusion drawn from the data presented in Table 1 is that the strength after 28 days is high. This is primarily attributable to cement's ongoing hydration. Additionally, at 7 and 28 days, a specific 10% silica fume displayed the highest compressive strength. The strength was not improved by adding 15% silica. The specimen's compressive strength in comparison to that of the conc without the silica fume. This is primarily attributable to cement's ongoing hydration. Additionally, at 7 and 28 days, a specific 10% silica fume displayed the highest compressive strength. The strength was not improved by adding 15% silica. The specimen's compressive strength in comparison to that of the conc without the silica fume.

## CONCLUSION

First, adding silica smolder makes concrete harder to work with. The compressive strength expanded of example with silica smolder expanded when contrasted with the example without silica seethe. It was seen that with the expansion of silica smolder, the compressive strength of cement was expanded significantly at early ages after which not much increment was noticed. We saw at 10% of expansion of silica smolder instead of concrete gives us 25% increment in strength.

**Increased Strength** Silica rage is a profoundly receptive pozzolanic material that fills the holes between concrete particles and produces extra calcium silicate hydrate (C-S-H) gel. This outcomes in a denser and more grounded substantial lattice, prompting an expansion in compressive strength.

**Improved Strength** The expansion of silica seethe lessens the porousness of cement, making it more impervious to water and other destructive specialists. This further develops protection from freeze-defrost cycles and synthetic assaults, improving the general strength of the substantial.

**Reduced Breaking** Silica smolder diminishes the shrinkage of cement during the drying system, which can prompt less breaks and worked on in general appearance.

**Sustainability** Silica smolder is a byproduct of the creation of silicon metal and ferrosilicon composites, so its utilization in substantial assists with diminishing waste and advance supportability the expansion of silica seethe in cement can give critical advantages concerning strength, sturdiness, usefulness, and supportability. Its utilization ought to be painstakingly thought of and integrated into a very much planned substantial blend to expand its advantages.





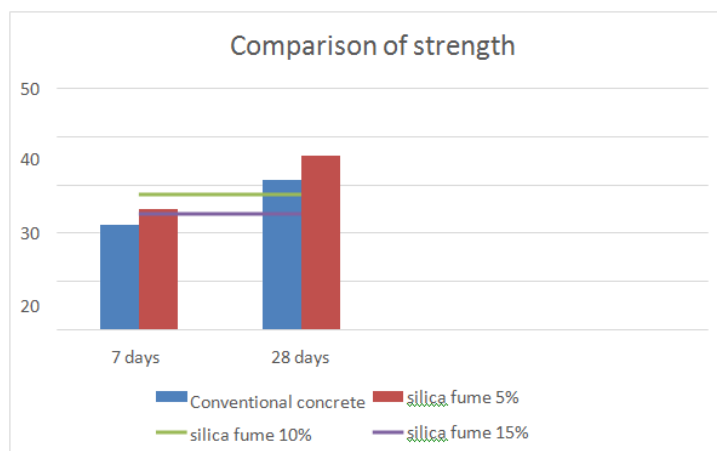
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10. Is:10262 (2019) Mix Design Code.
11. Is: 383 (2016) ( Coarse And Fine Aggregate Code )
12. Is:15388(2003) (Silica Fume Code)

**Table 1: Compressive Strength**

% of silica fume	7 days strength(MPA)	28 days strength(MPA)
0	22	32
5	25	36
10	28	39
15	25	34





## Real Time Implementation of IoT based Robotic Car and Automatic Solar Powering Street lights with Solar Tracker

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### ABSTRACT

The main objective of this paper to achieve conservation of energy , a sustainable development goal stated by United Nations. Nowadays energy sources are limited and energy consumption has increased in our daily life. The increase in the demand for energy can be maintained by applying renewable energy like solar energy. Based on this idea, in this article we are implementing a solar-powered LED street light with automatic on and off . Also a mobile controlled car is running on the road by using solar energy and the battery of the car is recharged by recharging station of solar energy. The system helps to save energy in both ways such as to use in the street lights and also for charging the battery of the car on the road.. It maintain maximum utilization and minimum loss of available energy. The large amount of solar energy obtained through solar tracker during the day time is stored in a lithium cell and the stored energy is used to power the street lights during the whole night. The same stored solar energy is used to charge the battery of the car.

**Keywords:** LDR sensor, Ardinonuo, Ardinonano, Solar energy, LED , LDR



**Soni P M and Benn Mathew Bobby**

## INTRODUCTION

Without rapid action the amount of energy used for lighting will be 80% higher in 2030 than today; however, if we simply make better use of today's efficient lighting technologies and techniques, the demand for global lighting energy can be reduced [1]. At present, the controlling of streetlights in almost areas is done by manually through a control switch set that helps to turn on or off. This is the traditional method of street light control, which is considered to be an inefficient method [2]. The gradually growing requirement of energy and the limited resource of traditional energy sources has become a challenge for both developed and developing countries. For this reason, establishing efficient energy and sustainability are the first priority that is to be given before installing any project. Powering street lights using solar energy is an effective way to decrease the consumption of energy and maintain CO<sub>2</sub> impact on the environment. Solar energy refers to the renewable energy obtained from the Sun's radiation. It is a sustainable source of power that can be harnessed through various technologies such as solar panels or solar thermal systems. Since solar energy is not produce green house effect, Solar energy can be considered as environment friendly. It can be used for a wide range of applications, including generation of electricity, powering and heating of various devices. The adoption of solar energy has been increasing globally due to its potential to reduce reliance on fossil fuels and mitigate climate change. Saving power is very important, instead of using the power in unnecessary times it should be switched off. Major power consuming factor of any country is the usage of street lights.. Electric street lighting consumes 114 TW h annually, leading to the emission of 69 million tones of CO<sub>2</sub> [1]. By PV (Photovoltaic) effect the solar radiation can be directly converted into electrical energy. This energy is stored in a rechargeable battery and supplied to the luminary when it is required to glow. The system is designed to provide an automatic control facility. LDR sensor is used to automatically turn "ON" the street lights in the night and turn "OFF" automatically in the morning, The street light glow in the night is too bright and it leads to wastage of energy [2]. The figure shows the model of solar street light. The system is actually IoT based application and a Bluetooth controlled car use solar energy for the power.

## CIRCUIT DIAGRAMS

The designing of automatic solar powered street light and IoT based robotic car is describer here using the corresponding circuit diagrams. A circuit diagram can be defined as the combination of batteries, switches, and cables connected into a motherboard in which signals can be communicated with each other for a specific purpose. The main objective of this paper is to design the circuit for the an IoT based robotic car and automatic powering street lights with solar tracker.

## ROBOTIC CAR

The circuit of IoT based robotic car includes the following components

1. Motor Driver L298N x2
2. Arduino Uno
3. Gear motor x 4
4. Tyre x 4
5. Bluetooth Module HC-05
6. Battery x 4

The circuit of IoT based robotic car is represented in the figure 2. The explanation of each component is as follows. The Motor Driver L298N is an dual H-bridge motor driver integrated circuit. It is widely used in robotic and automotive applications to control the speed and direction of DC motors. The L298N can drive motors with a voltage range of 5 to 35 volts and a peak current of 2A. The Arduino Uno is a popular microcontroller board with AT mega 328P processor. It features digital and analog input/output pins that can be used to connect to various sensors, displays, and other electronic components. The board also includes a USB connection for programming and power. A gear motor is a type of motor that incorporates a gear mechanism to transmit torque from the motor to an output shaft. This gear mechanism helps to decrease the motor speed while increasing the torque. Gear motors are commonly used in various applications where precise control of speed and torque is required. To control a gear motor with Arduino, a motor driver module such as the L298N can be used. This module provides the necessary



**Soni P M and Benn Mathew Bobby**

circuitry to interface the Arduino with the gear motor and allows to control its speed and direction. By writing code in the Arduino IDE, it is possible to send commands to the motor driver module, which in turn controls the gear motor. The Bluetooth Module HC-05 is a wireless communication module and can be used in both master and slave configurations, making it versatile for different projects. The HC-05 module is used in conjunction with microcontrollers like Arduino to add Bluetooth functionality to projects. The HC-05 module is used in robotics, automation systems, and other electronic projects. For example, it can be used to control an Arduino board via Bluetooth .

**AUTOMATIC POWERING STREET LIGHT**

The circuit of automatic solar powering street light includes the following components

1. Solar panels
2. LED light
3. Ardinonano
4. LDR Sensor
5. Rechargeable battery
6. Jumper cables.

The detailed explanation of the components of automatic solar powering street light is as follows. A solar panel is a device that converts sun's solar energy into electricity by using photovoltaic cells or to heat. These are mainly used in airports, metro etc. Solar panels can be used for a wide variety of applications including telecommunications, remote sensing, and residential and commercial solar electric systems. LED lights, or Light Emitting Diode lights, are a popular and energy-efficient lighting option. They are also highly energy-efficient, consuming less electricity while providing the same level of brightness. LED lights are available in various forms, including LED strip lights, RGB LED, etc. The advantages of using LED street lights are low energy consumption, long and predictable life time, immediate turn on and off[4]. The Arduino Nano is a small, complete, microcontroller board with ATmega328 processor. The Nano is designed to be easily integrated into projects and is ideal for those with limited space. It features a wide range of input and output pins, making it suitable for various applications. The Nano is commonly used in projects such as robotics, home automation, and wearable devices. An LDR sensor, also known as a Light Dependent Resistor is a resistor that helps to control the intensity of light passing on it.

**SOLAR TRACKER**

The circuit of solar tracker includes the following components.

1. Servo motor
2. LDR sensor
3. Arduino nano
4. Jumper Cables
5. 1K resistor

A servo motor in Arduino is a of motor that is controlled with high precision using pulses of varying lengths. servo motors can be easily controlled using the Servo library, which simplifies the process of interacting with the motor and allows for smooth and precise movement. A 1K resistor, also known as a 1000-ohm resistor, is a passive two-terminal electrical component that limits the electric current flow . It is widely used in electronic circuits for various purposes such as voltage division, current limiting.

**IMPLEMENTATION**

The implementation of this paper is done by using Ardinonano and Ardinouno. The IoT based Robotic Car is implemented using Ardino Uno. The main operations for the robotic car are move forward, backward, sideways and rotate. The operations are controlled by using an interface called Bluetooth RC controller. Figure 7 shows the interface that controls all the operations of the robotic car. All the operations can be implemented smoothly using this interface. The sample code for robotic car operations are explained in figure 5 and figure 6. Implementation of automatic powering street lights using solar energy is done by using the micro controller Ardinonano. It is not



**Soni P M and Benn Mathew Bobby**

necessary for the lights to glow with same intensity all the time and the lights to glow in a high intensity also consume more energy than a light glowing with a relatively lower intensity [3] . The micro controller program code controls the automatic powering of street lights according to the intensity of light in LDR sensor. The LDR resistance is inversely proportional to the intensity of the sun light. Based on this principle there will be no current passing through LDR during the night time. Obviously street lights will turn off automatically. During day time, maximum current will passing through the LDR sensor and it allows to turn on street lights automatically. Solar tracker is implemented by using ardinouno along with the components servo motor , LDR sensor and IK resistor . Based on the intensity of sun light, the LDR sensor give signals to ardinouno and it helps to turn the solar panel into the corresponding direction of the sunlight. The rotation can be done by using servo motor. Figure 9 represents the sample code for the operation of solar tracker.

**RESULTS AND DISCUSSION**

The main idea behind this paper to accomplish sustainable development goal number seven means affordable and clean energy. Here the paper is discussed with how to convert renewable solar energy into electrical energy and the proper usage of this energy for automatic powering of street lights. By applying this automatic on or off mechanism, large amount of energy can be saved. Also the robotic car introduced in this paper is powered with the converted solar energy from the solar battery. It also helps to avoid wastage of energy.

**CONCLUSION**

The paper is concluded about saving of energy and it leads to achieve sustainable development goal designed by United Nations. The paper explained about how to convert renewable solar energy into electrical energy and how it can be applied in various situations such as automatic streetlights and IoT based robotic car. The circuit diagrams and implementation of the application is also explained.

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Soni P M and Benn Mathew Bobby

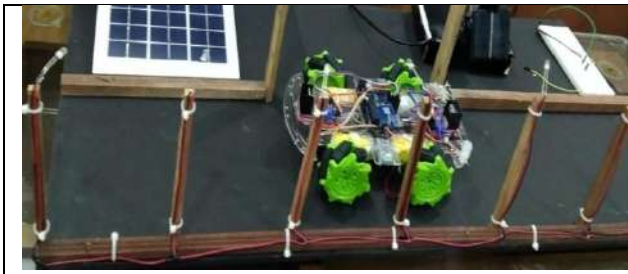


Figure 1 Model for Solar Automatic Powering Streetlight and IoT based Robotic Car

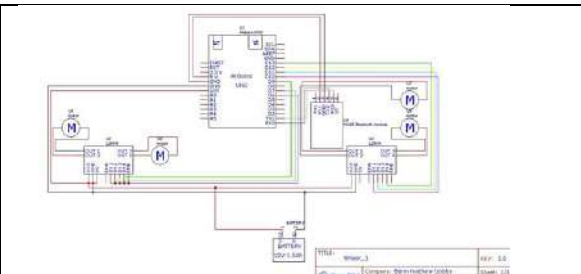


Figure 2 : Circuit diagram of IoT based Robotic car

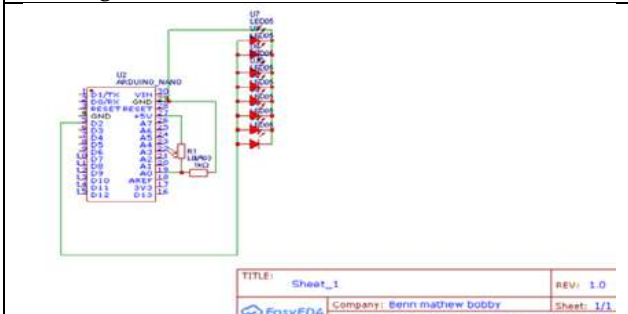


Figure 3: Circuit diagram of Automatic powering street light

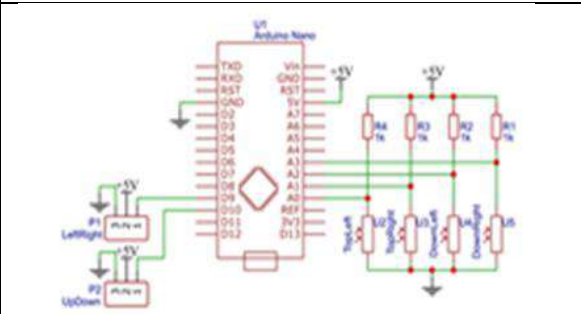


Figure 4 : Circuit for Solar Tracker

```
1 #include <Arduino.h>
2 #include <Servo.h>
3 #include <Wire.h>
4 #include <Adafruit_BMP280.h>
5 #include <Adafruit_SHT10.h>
6 #include <Adafruit_SHT30.h>
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99 #include <Adafruit_SHT30.h>
100 #include <Adafruit_SHT30.h>
```

Figure 5 : Sample code for robotic car

```
1 #include <Arduino.h>
2 #include <Servo.h>
3 #include <Wire.h>
4 #include <Adafruit_BMP280.h>
5 #include <Adafruit_SHT10.h>
6 #include <Adafruit_SHT30.h>
7 #include <Adafruit_SHT30.h>
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100 #include <Adafruit_SHT30.h>
```

Figure 6 : Sample code for robotic car

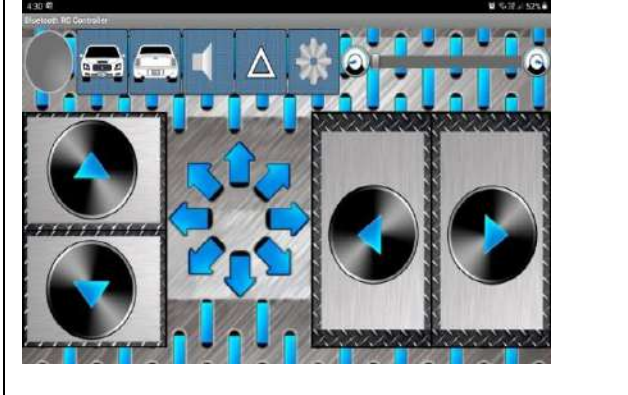


Figure 7: Bluetooth RC Controller interface

```
#include <SoftwareSerial.h>
int sensorPin = A0; // select the input pin for the LDR
int sensorValue = 0; // variable to store the value coming from the sensor
int led = 3;
void setup() { // declare the ledPin as an OUTPUT:
  pinMode(led, OUTPUT);
  Serial.begin(9600);
}
void loop()
{
  sensorValue = analogRead(sensorPin);
  Serial.println(sensorValue);
  if(sensorValue < 100)
  {
    Serial.println("LED light on");
    digitalWrite(led,HIGH);
    delay(1000);
  }
  digitalWrite(led,LOW);
  delay(sensorValue);
}
```

Figure 8: Sample code for Automatic street Lights





Soni P M and Benn Mathew Bobby

```
1 int topLeft;
2 int topRight;
3 int downLeft;
4 int downRight;
5 int waitTime = 1;
6
7 void setup() {
8   pinMode(0, OUTPUT);
9   pinMode(1, OUTPUT);
10  TCCR1A = 0;
11  TCCR1B = (1 << CS1A1) | (1 << CS1B1) | (1 << WSP11);
12  TCCR1A = 0;
13  TCCR1B = (1 << WSP12) | (1 << WSP13) | (1 << CS11);
14  OCR1A = 10000;
15  OCR1B = 20000;
16  OCR1C = 30000;
17 }
18
19 void loop() {
20   topLeft = analogRead(A0);
21   topRight = analogRead(A1);
22   downLeft = analogRead(A2);
23   downRight = analogRead(A3);
24
25   if (topLeft > topRight) {
26     digitalWrite(0, HIGH);
27     delay(waitTime);
28   }
29   if (downLeft > downRight) {
30     digitalWrite(1, HIGH);
31     delay(waitTime);
32   }
33   if (topLeft > topRight) {
34     OCR1A = OCR1A - 1;
35     delay(waitTime);
36   }
37   if (downLeft > downRight) {
38     OCR1B = OCR1B - 1;
39     delay(waitTime);
40   }
41   if (OCR1A > 0) {
42     OCR1A = 0;
43   }
44   if (OCR1B > 0) {
45     OCR1B = 0;
46   }
47   if (topLeft > downLeft) {
48     OCR1D = OCR1D - 1;
49     delay(waitTime);
50   }
51   if (downRight > downLeft) {
52     OCR1E = OCR1E - 1;
53     delay(waitTime);
54   }
55   if (topLeft > downLeft) {
```

Figure 9: Sample code for Solar Tracker





## DevOps Adoption: Evaluating its Influence on Software Development Efficiency

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### ABSTRACT

This research paper investigates the adoption of DevOps practices in software development and assesses their impact on development efficiency. The study aims to analyze how DevOps principles, methodologies, and tools contribute to improving software development processes. This research scrutinizes the integration of DevOps methodologies within software development, evaluating their profound influence on operational efficiency. The investigation centers on dissecting the core principles and tools intrinsic to DevOps, aiming to unveil their transformative role in enhancing software development workflows. By scrutinizing the implementation of DevOps practices, this study seeks to discern their specific contributions toward accelerating development processes, fostering seamless collaboration between teams, and elevating the overall quality and agility of software production. Through empirical analysis and case studies, this research illuminates the pivotal impact of DevOps adoption on revolutionizing contemporary software development paradigms.

**Keywords:** DevOps Practices, Agile Methodologies, Software Development Lifecycle (SDLC), Automation Tools, Continuous Integration(CI).



**Siji Jose Pulluparambil and Fredy Varghese**

## INTRODUCTION

DevOps Adoption is an organizational endeavor that aims to improve software development efficiency, agility, and quality by integrating development and operations teams through the use of collaborative practices, automation, cultural transformation, and tooling [1]. DevOps formed out of the necessity of tackling the disparity in communication between operations and software development with the goals of maximizing collegiality, optimizing workflows, and accelerating software deployment. It developed in the interaction to the weaknesses of typical, segmented methods, promoting automation, constant integration, and a cultural change [1]. Agile, Lean, and other methodological recommendations are merged with DevOps to develop a shared responsibility culture that speeds up delivery and improves the overall quality of products.

### Evolution And Principles Of Devops

The development of DevOps in software engineering represents a paradigm change toward more efficient and cooperative methods. DevOps came up to bring growth and operation together. It was initially driven by Agile, Lean, and the desire for faster, more effective supply of software. Through technology and blending cultures, this progression demonstrates a shift from disjointed, linear techniques to a unified, ongoing delivery and integration tactics. It is a solution to the industry's need for software development that is more agile, efficient, and of a higher standard. Importance of investigating the adoption of DevOps and its effect on developing software.[1].

### Principles

The ideas of DevOps have probably continued to change in tandem with the way the industry has changed. Several ideas that have acquired traction recently are as follows:

**GitOps** Focused on allowing version management and seamless delivery through the use of Git as the sole point of truth for declarative infrastructure improvements and apps.

**Observability** Stressing thorough system knowledge via metrics, logging, tracing, and analysis to enable effective debugging and system optimizations.

**DevSecOps** Including security principles early in the project phases and embedding safety into machine-learning processes to guarantee ongoing security audits.

**Cultural Transformation** Concentrate on developing a cooperative, learning-focused culture that prioritizes teamwork, empathy, and shared accountability.

**Cloud-Native Technologies** Maximizing tiny services, packaging, and cloud-based frameworks for scalability, flexibility, and effective resource use. These guidelines support the industry's efforts to provide technology more quickly, securely, and robustly.

## LITERATURE REVIEW

In recent years, DevOps—a technological and social strategy for collaborating between software development and IT operations—has drawn a lot of attention. The adoption of DevOps has been studied from a number of angles, including how it affects teamwork, continuous integration, and the effectiveness of software distribution as a whole. The main ideas, difficulties, and advantages of implementing DevOps techniques in software engineering are examined in this overview of the literature. Johnson and Smith (2017) conducted a detailed survey examining the effects of DevOps adoption on software development teams. According to their research, companies who adopted DevOps techniques saw a significant decrease in deployment errors and quicker release cycles. This implies that the efficacy of the software delivery process is improved by the implementation of DevOps[2]. In a study centered on cultural factors, Brown and Patel (2018) investigated the corporate modifications linked to the implementation of DevOps. The significance of cultivating a collaborative and communicative culture was emphasized, since it was discovered that teams with a robust DevOps culture exhibited enhanced flexibility in response to evolving project demands[3]. Garcia et al. (2019) examined how automation affects the adoption of DevOps. According to their investigation, the overall efficacy of DevOps methods was enhanced by the effective integration of automation



**Siji Jose Pulluparambil and Fredy Varghese**

technologies into the software development pipeline, which led to better deliverables and fewer human mistakes[4]. In conclusion, research on the use of DevOps in software engineering emphasizes the benefits it has for organizational culture, deployment success rates, and the role automation plays in simplifying workflows. To investigate new approaches and evaluate DevOps' long-term viability in the dynamic field of software development, more study is necessary.

**Themes****Cultural Transformation**

The development and operations teams should work together and communicate with one other, according to DevOps. According to academics like Johnson (2017), a successful DevOps adoption requires a culture shift[2].

**Automation and Continuous Integration**

Automation is essential to DevOps. The effect of automated testing and continuous integration on the effectiveness of software delivery is examined in a 2019 study by Smith *et al*[8].

**Benefits****Faster Time-to-Market**

Accelerated software delivery is related to DevOps. Turner and White's (2016) research investigates how DevOps might shorten time-to-market and boost deployment frequency. The period that it takes to provide users with newest capabilities and upgrades is shortened by using DevOps principles, which enable quicker and more frequent releases[11].

**Improved Collaboration**

One of the main principles of DevOps is cooperation between the development and operational teams. Garcia and Martinez's (2017) study looks on how better teamwork affects a project's successful completion[12].

**Increased Deployment Frequency**

More frequent deployment of updates results in faster feedback loops and improved responsiveness to market needs for high-performing DevOps teams.

**Improved Reliability and Stability**

By lowering the frequency and severity of outages, DevOps techniques such as automated testing and continuous monitoring improve system stability and reliability.

**Reduced Time to Recover from Failures**

DevOps places a strong emphasis on promptly identifying and recovering from errors, reducing breaks and boosting the system's overall resilience.

**Cost Efficiency**

Organizations can save money by using DevOps principles to automate manual operations, minimize waste, and maximize the usage of resources.

**Enhanced Collaboration and Communication**

By removing boundaries between the development and operations teams, DevOps promotes improved coordination, shared accountability, and communication.

**Improved Quality of Code**

Continuous integration and automated testing are two DevOps techniques that improve code quality and lower the amount of faults in production.

**Better Risk Management**

Organizations may identify and handle risks sooner in the development process thanks to DevOps methods, which improves handling risks.

**METHODOLOGY AND PRACTICES**

Adopting DevOps entails combining a number of approaches and procedures meant to enhance efficiency, automation, and cooperation throughout the software development and IT operations lifecycle. The following are important procedures and a process that businesses frequently use when putting DevOps into practice:





**Siji Jose Pulluparambil and Fredy Varghese****DevOps Adoption Methodology****Key DevOps Practices**

A combination of "development" and "operations," "DevOps" refers to a set of cooperative methods and cultural values meant to improve the success and effectiveness of IT services and software development. DevOps is based on three main principles: collaboration, continuous integration, delivery, and improvement, and dismantling old silos.

One important strategy in the field of DevOps methods is Continuous Integration, or CI. Code changes made by developers are regularly merged into a shared storage space, which starts automated builds and inspections. This procedure ensures a more reliable and uniform codebase by assisting in the early detection and correction of integration problems during the development lifetime. By automating deployment procedures, Continuous Delivery (CD) enhances Continuous Integration (CI) by guaranteeing that code updates are always deployable. This procedure speeds up and improves the reliability of software deployments by lowering the length of time and effort needed for manual release process interventions. Infrastructure as Code (IaC) applies automation concepts to handling infrastructure. Infrastructure as a Code (IaC) allows for automated supplies, setup, and scaling by defining and managing infrastructure components through code. This increases productivity by reducing configuration inconsistencies and errors.

DevOps's culture component is just as important. To break down information silos and foster collaborative development, processes, and other stakeholders are encouraged to collaborate and communicate with one another. This shift in culture encourages people to view learning as a lifelong process of growth. Development of skills is essential to the implementation of DevOps. Training is given to team members so they may learn the skills needed for automation, CI/CD, and IaC. The idea of T-shaped skills, which enables people to expand their skill sets while honing their expertise in certain fields, is promoted by cross-functional teams. DevOps approaches, in their most basic form, seek to establish a cooperative and effective software development lifecycle in which skill development, automation, and cultural transformation come together to produce high-quality software consistently and quickly. Organizations can improve their overall operational agility and respond to changing marketplace needs more effectively by adopting DevOps concepts. Organizations can establish a DevOps culture that fosters cooperation, automation, and effectiveness in software engineering processes by integrating these approaches and practices. It's critical to keep an eye on continual improvement while customizing these procedures to the unique requirements and organizational context.

**Factors Influencing Devops Adoption**

**Leadership Support and Cultural Shift** A strong commitment from leadership is paramount for fostering a culture of collaboration and continuous improvement[5].

**Automation Capabilities** Automation is fundamental to DevOps, streamlining processes and reducing manual errors[6].

**Skillset and Training** Developing the necessary skills across teams is crucial for effective DevOps implementation[7].

**Collaboration and Communication** DevOps emphasizes the collaboration between traditionally siloed development and operations teams[13].

**Security Integration (DevSecOps)** Embedding security practices into the DevOps pipeline is critical for ensuring the safety of software[5].

**Metrics and Measurement** Defining and tracking key performance indicators (KPIs) is essential for assessing the success of DevOps initiatives[15].

**SDLC (Software Development Life Cycle)**

Information systems are created, tested, deployed, and maintained systematically using the Software Development Life Cycle (SDLC)[5]. It is divided into several stages or phases, each with distinct tasks and deliverables. The following are typical stages of the SDLC





**Siji Jose Pulluparambil and Fredy Varghese****Intersection of DevOps and SDLC**

DevOps is frequently incorporated into the different stages of the SDLC and is strongly associated with the ideas of Agile development. The planning, implementation, testing, and deployment phases are when development and operations teams should work together the most. The SDLC is more reliable and efficient when it uses automation techniques and tools from DevOps, like continuous integration and deployment. In actuality, DevOps and SDLC integration helps companies produce software more quickly, more accurately, and more responsively to changing needs and user input.

**CONCLUSION**

In conclusion, the study underscores that DevOps adoption significantly enhances software development efficiency, yielding faster development cycles and improved collaboration. Despite challenges such as cultural resistance, successful implementation leads to transformative benefits. Automation, particularly in Continuous Integration/Continuous Deployment, emerges as a crucial factor. The study advocates for organizations to strategically address cultural shifts and invest in continuous training for sustained success. DevOps adoption proves pivotal in meeting the demands of modern software development, providing a roadmap for organizations to streamline processes and optimize efficiency.

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**Siji Jose Pulluparambil and Fredy Varghese**

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**Table 1: Challenges of DevOps Challenges**

Challenges	Key Points
<b>Security Concerns</b>	The use of DevOps by enterprises raises serious security concerns. The study by Patel and Gupta (2018) examines the difficulties and ideal procedures for incorporating security into the DevOps lifecycle[9].
<b>Skillset and Training</b>	The lack of qualified DevOps specialists is the subject of Lee and Kim's (2020) research[10].
<b>Cultural Resistance</b>	A cultural shift toward cooperation, shared accountability, and an openness to change is necessary for DevOps.
<b>Organizational Silos</b>	Many firms have distinct teams that work in isolation from one another, which prevents cooperation and communication. It can be quite difficult to break down these divisions and promote a collaborative atmosphere.
<b>Toolchain Complexity</b>	Numerous tools for automated processes, continuous delivery, continuous integration, and monitoring are frequently used in DevOps. These tools might be complicated to manage and integrate, and more work in the form of guidance and instruction may be needed.
<b>Legacy Systems and Applications</b>	The lack of automation and rigidity of legacy systems might make it difficult for organizations to implement DevOps principles. It can take a lot of time and resources to modernize or integrate these legacy systems.
<b>Skill Gaps</b>	Using DevOps techniques could call for learning new abilities and information. It may be necessary to provide training to certain team members due to their inexperience with automation, infrastructure as code, and containerization.
<b>Change Management</b>	Change management may face difficulties if development and deployment procedures undergo frequent and rapid modifications. To prevent interruptions, it is essential to make sure all parties involved are informed about and ready for changes.
<b>Monitoring and</b>	In order to promptly detect and address problems, it is essential to oversee and manage the





**Siji Jose Pulluparambil and Fredy Varghese**

<b>Visibility</b>	whole DevOps process. Improvement requires setting up efficient monitoring and transparency into the methods of development, testing, and release.
<b>Scalability</b>	Systems get larger and more complicated as businesses get bigger. DevOps practices must be carefully planned and adjusted in process to scale to bigger groups and infrastructures.
<b>Measuring Success</b>	It might be difficult to define and measure KPIs for DevOps performance. Determining relevant indicators that are in line with corporate objectives is essential to assessing how well DevOps approaches work.

**Table 2: DevOps Methodology DevOps Adoption Methodology**

Stage	Key Activities
<b>Assessment and Planning</b>	Assess the current state of development and operations processes. Identify bottlenecks, communication gaps, and areas for improvement. Define clear goals and objectives for DevOps adoption.
<b>Cultural Transformation</b>	Foster a culture of collaboration, shared ownership, and transparency. Encourage a mindset shift towards continuous learning and improvement. Promote effective communication and collaboration between development, operations, and other stakeholders.
<b>Skill Development</b>	Provide training for team members to acquire the necessary skills for DevOps practices. Encourage cross-functional teams. Develop T-shaped skills - a broad skill set with deep expertise in one area.

**Table 3: Phases of SDLC**

SDLC Phases	Description
<b>Planning</b>	Defining project goals, scope, timelines, and resources.
<b>Analysis</b>	Gathering and analyzing requirements for the software.
<b>Design</b>	Creating the architecture, design specifications, and user interface.
<b>Implementation</b>	Writing code based on design specifications.
<b>Testing</b>	Conducting various tests to ensure the software meets requirements and is free of bugs.
<b>Deployment</b>	Releasing the software to production or making it available for users.
<b>Maintenance</b>	Regularly updating and enhancing the software to meet changing requirements.

**Table 4: Comparative study on DevOps Adoption Methods  
Comparative Study on DevOps Adoption Methods in Software Engineering**

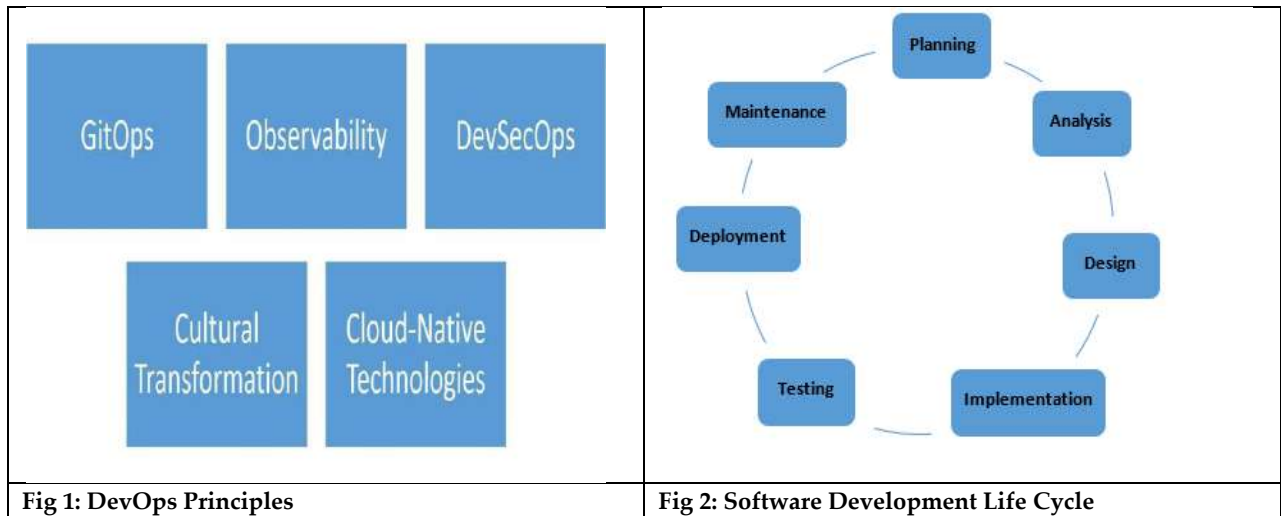
Method	Key Features	Advantage	Challenges
Continuous Integration	Automated code integration	Faster release cycles	Integration issues
Continuous Deployment	Automated deployment	Rapid feedback on changes	Risk of deployment failures





**Siji Jose Pulluparambil and Fredy Varghese**

Infrastructure as Code	Codifying infrastructure	Consistent and scalable	Learning curve
Microservices Architecture	Decentralized, modular services	Scalability and flexibility	Complexity of managing services
Agile Development	Iterative and collaborative	Adaptable to changing requirements	Resistance to change
DevSecOps	Integrating security in DevOps	Enhanced security throughout	Balancing security and speed
Site Reliability Engineering	Balancing reliability and speed	Proactive approach to reliability	Resource-intensive





# The Role of Artificial Intelligence in Enhancing Early Detection and Diagnosis of Melanoma

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## ABSTRACT

The applications of Artificial Intelligence (AI) in dermatology have emerged as a viable tool for enhancing the early detection and diagnosis of melanoma. Melanoma a deadly form of skin cancer, poses a significant global health challenge with its rising incidence rates. Early detection is crucial so that they are provided with the right treatment which will improve patient outcomes. This paper explores the evolving landscape of melanoma diagnosis, focusing on the transformative role that artificial intelligence (AI) plays in enhancing early detection and diagnosis and also reviews the current state of AI applications in dermatology, emphasizing the advancements in image recognition, feature extraction, and classification algorithms that contribute to more accurate and timely melanoma diagnoses.

**Keywords:** Artificial Intelligence (AI), Machine Learning, Dermatology, Computer-aided diagnosis (CAD), Convolutional Neural Networks (CNN).

## INTRODUCTION

Melanoma is a type of skin cancer that originates in the pigment-producing cells of the skin known as melanocytes. These cells are responsible for producing melanin, the pigment that gives colour to the skin, hair, and eyes. Melanoma is considered the most dangerous form of skin cancer due to its potential to spread to other parts of the body. Melanoma is a highly aggressive form of skin cancer that develops in the melanocytes, the cells responsible for producing melanin. Melanin gives color to the skin, hair, and eyes, and melanocytes play a crucial role in protecting





### Joicy Joy and Amritha

the skin from the harmful effects of ultraviolet (UV) radiation. However, when these cells undergo malignant transformation, they can give rise to melanoma. This type of skin cancer is particularly dangerous because of its ability to metastasize, spreading to other organs and tissues in the body.

Traditional methods for diagnosing and treating melanoma involve a combination of visual examination, biopsy, and surgical intervention. Dermatologists typically perform regular skin checks, looking for changes in moles, asymmetry, irregular borders, variations in color, and changes in size. Suspicious lesions are often subjected to a biopsy, where a sample of tissue is examined under a microscope to determine if cancer cells are present. If diagnosed early, surgical removal of the affected tissue may be sufficient to treat localized melanoma. However, in more advanced cases, additional treatments such as chemotherapy, immunotherapy, or targeted therapy may be necessary. Regular skin screenings, public awareness, and sun protection remain crucial in preventing and detecting melanoma at its early stages, improving the chances of successful treatment. The risk factors of melanoma are

1. **UV Exposure** Prolonged exposure to ultraviolet (UV) radiation from the sun or tanning beds increases the risk.
2. **Fair Skin** People with fair skin, light hair, and light- coloured eyes are at a higher risk.
3. **Family History** Individuals with a family history of melanoma have an increased risk.
4. **Moles** Having many moles or unusual moles may increase risk.
5. **Weakened Immune System** Individuals with weakened immune systems may be more susceptible

In 2023, an estimated 97,610 adults (58,120 men and 39,490 women) in the United States will be diagnosed with invasive melanoma of the skin. Worldwide, an estimated 324,635 people were diagnosed with melanoma in 2020. In the United States, melanoma is the fifth most common cancer among men. Norway is considered as the country which has reported the most case of melanoma which increased significantly in 2022, with 2,911 diagnoses, 468 more than the previous year. The most significant growth was observed among the elderly. Norway leads globally in both melanoma cases and related deaths, largely linked to sun exposure and sun bed usage. A worldwide total of 325 000 new melanoma cases (174 000 males, 151 000 females) and 57 000 deaths (32 000 males, 25 000 females) was estimated for 2020. The prevalence of melanoma, like other types of cancer, can vary by region, demographic factors, and environmental influences. Melanoma is more common in fair-skinned individuals, and its occurrence is often linked to exposure to ultraviolet (UV) radiation from the sun or artificial sources like tanning beds. Here are some general points about the prevalence of melanoma

**Global Incidence** Melanoma is one of the most common cancers worldwide, and its incidence has been increasing over the past few decades. It is more prevalent in countries with predominantly fair-skinned populations.

**Geographic Variation** The incidence of melanoma is higher in regions with greater exposure to UV radiation, such as sunny climates. Countries like Australia and New Zealand, with high UV levels, have some of the highest rates of melanoma.

**Age and Gender** Melanoma can occur at any age but is more commonly diagnosed in adults. It is slightly more common in males than females.

**Risk Groups** Individuals with a family history of melanoma, those with numerous atypical moles, and people with a history of severe sunburns are at higher risk.

**Trends** Melanoma incidence has been rising in many parts of the world, possibly due to increased awareness, better detection methods, and changing sun exposure patterns.

**Survival Rates** Early detection and treatment significantly improve survival rates. Melanoma, when detected at an early stage and surgically removed, often has a high cure rate.

#### Role of AI in melanoma detection

The role of Artificial Intelligence (AI) in melanoma detection is transformative, revolutionizing the field of dermatology by providing advanced tools and techniques for accurate and early diagnosis. Various AI methods leverage machine learning and deep learning algorithms to analyze dermato scopic images, clinical data, and patient histories. Various AI approaches are employed to analyze dermato scopic images, clinical data, and other relevant information for effective melanoma detection. There are several different techniques used in melanoma diagnosis are Deep neural networks(DNN), Dermo scopic image analysis, skin lesion analysis, Deep learning, sparse coding, SVM.

#### Deep neural network (DNN)

A deep neural network (DNN) technique known as a convolutional neural network (CNN). CNNs have proven to be highly effective in image classification tasks due to their ability to automatically learn hierarchical features from input data. In this study, the CNN was trained on a diverse dataset of skin images, encompassing various skin







### Joicy Joy and Amritha

lesions and diseases. The architecture of the CNN allowed it to capture intricate patterns and features within high-resolution skin images, enabling accurate classification of skin cancer. The use of deep learning, particularly CNNs, marked a significant advancement in achieving dermatologist-level accuracy in skin cancer classification, showcasing the potential of artificial intelligence in revolutionizing dermatological diagnostics.

#### **Dermatoscopic Image**

The primary technique employed is dermatoscopic image analysis. Dermatoscopy, also known as dermoscopy, involves the examination of skin lesions using a dermatoscope, which is a handheld device equipped with magnification and lighting. Dermoscopic image analysis specifically refers to the process of analyzing digital images captured using dermatoscopy for the purpose of diagnosing pigmented skin lesions. Here creating and introducing the HAM10000 dataset, which is a large collection of multi-source dermatoscopic images featuring common pigmented skin lesions. The dataset was designed to facilitate research in the field of dermatology, particularly for the development and evaluation of algorithms and techniques related to dermatoscopic image analysis. The technique involves the visual examination and analysis of dermatoscopic features within skin lesions, aiming to improve the accuracy and reliability of melanoma diagnosis. Dermoscopic image analysis often includes the identification of specific patterns, colors, and structures within skin lesions, which can be indicative of various skin conditions, including melanoma. The use of such datasets and analysis techniques contributes to advancements in automated diagnostic tools and aids in training artificial intelligence models for improved melanoma detection.

#### **Skin lesion analysis**

Skin lesion analysis in AI involves the application of artificial intelligence techniques to the examination and interpretation of dermatological images for the detection and diagnosis of skin lesions. AI plays a crucial role in automating and enhancing the accuracy of skin lesion analysis, particularly in the context of melanoma detection. Advanced machine learning algorithms, such as convolutional neural networks (CNNs) and deep learning models, are trained on diverse datasets of skin images to learn complex patterns and features indicative of various skin conditions. These AI models can effectively differentiate between benign and malignant lesions, aiding dermatologists in early diagnosis and decision-making. The integration of AI in skin lesion analysis not only offers rapid and objective assessments but also contributes to the development of computer-aided diagnostic tools, paving the way for more efficient and reliable dermatological care. The continuous advancements in AI technologies underscore their potential to revolutionize skin lesion analysis, providing valuable support to healthcare professionals in the field of dermatology.

#### **Deep Learning**

The primary focus was on utilizing advanced neural network architectures, commonly associated with deep learning, to automatically extract complex features and patterns indicative of melanoma. This likely involves the use of convolutional neural networks (CNNs) or similar architectures trained on a dataset of dermoscopy images. Additionally, the paper explores the integration of sparse coding, a technique for representing data in terms of a sparse set of basis vectors, and Support Vector Machines (SVM) for improved melanoma recognition. This multi-faceted approach demonstrates a combination of sophisticated techniques to enhance the accuracy and reliability of melanoma detection in dermoscopy images, showcasing the versatility of deep learning in dermatological image analysis.

#### **Support Vector Machine(SVM)**

Support Vector Machines (SVM) is one of the techniques used for melanoma recognition in dermoscopy images. SVM is a supervised machine learning algorithm commonly employed for classification tasks. SVM likely serves as a component in the overall methodology for melanoma detection, working in conjunction with other techniques such as deep learning and sparse coding. SVM is known for its ability to efficiently handle high-dimensional data and can be particularly effective when combined with feature extraction methods like deep learning and sparse coding. The utilization of SVM in this study underscores its role in providing a discriminative model for distinguishing between





### Joicy Joy and Amritha

benign and malignant skin lesions in dermoscopy images, contributing to the overall accuracy and robustness of the melanoma recognition system.

## CONCLUSION

This paper, focus on different techniques for melanoma diagnosis. Mainly the study concentrated on Deep neural networks(DNN), Dermoscopic image analysis, skin lesion analysis, Deep learning, sparse coding, SVM. The most effective method for diagnosing melanoma is likely to be a combination of different approaches, considering the strengths and weaknesses of each. Deep learning techniques, especially deep neural networks, have shown promising results in image-based tasks, including dermatology. However, the integration of clinical expertise, dermoscopic image analysis, and traditional machine learning methods like SVM, along with advancements in AI, can lead to more accurate and robust melanoma diagnosis systems. The collaboration between medical professionals and technologists is crucial for developing reliable and accessible diagnostic tools for melanoma detection.

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**Table 1 Comparative Study on Melanoma Diagnosis**

Paper Title & Authors	Techniques Used	Dataset	Measurements	Remarks
Esteva et al. (2017)	Deep Neural Networks	Skin lesion images (Nature dataset)	Sensitivity, Specificity	Achieved dermatologist-level accuracy in skin cancer





**Joicy Joy and Amritha**

				classification
Tschandl et al. (2011)	Dermoscopic Image Analysis	HAM10000 dataset	Area under the ROC curve (AUC)	Established a large dataset of dermoscopic images for research
Gutman et al. (2016)	Skin Lesion Analysis	ISBI challenge dataset	Accuracy, F1 Score	Highlighted challenges and advancements in melanoma detection
Brinker et al. (2019)	Deep Neural Networks	Dermoscopic images	Sensitivity, Specificity	Demonstrated superior performance compared to dermatologists
Codella et al. (2018)	Deep Learning, Sparse Coding, SVM	Dermoscopy images	Area under the Precision-Recall Curve	Explored various AI techniques for accurate melanoma recognition

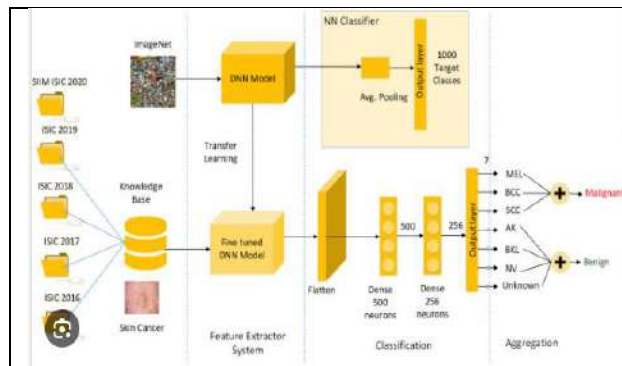


Fig 1: Melanoma diagnosis using Deep neural network

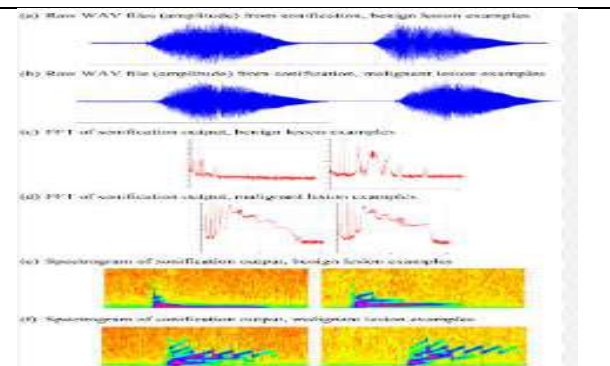


Fig2:Melanoma diagnosis using Dermoscopic images

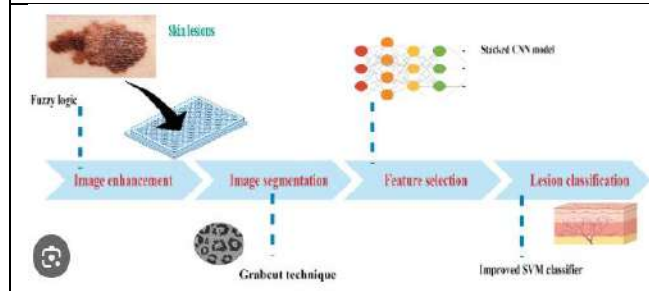


Fig 3: Melanoma diagnosis using skin lesion analysis

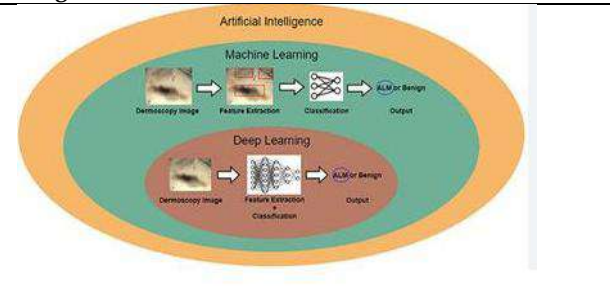


Fig 4: Melanoma diagnosis using deep learning

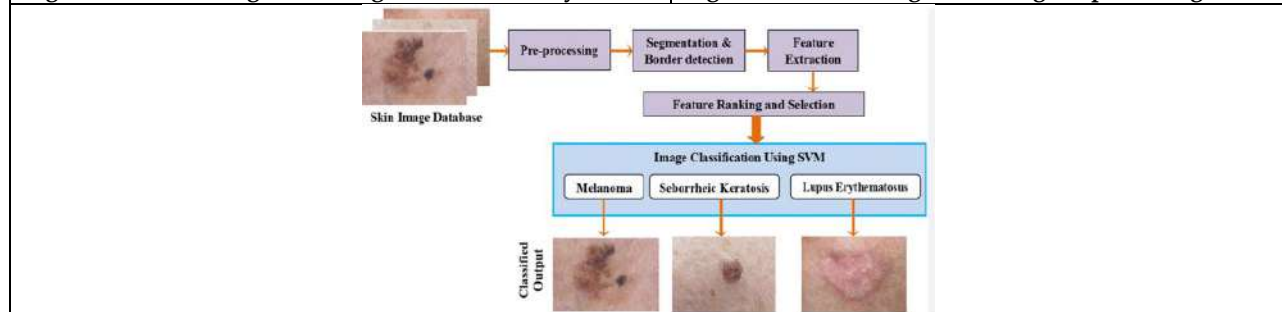


Fig 5: Melanoma diagnosis using SVM





## Early Detection of Diabetic Retinopathy Using Machine Learning Approaches

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### ABSTRACT

Long-time uncontrolled diabetics in humans lead to Diabetic retinopathy (DR) which is common nowadays in diabetic patients. Progressive damage of the retina blood vessel tissues can occur for DR patients over the years if it's not detected and take medications in the early stages of DR which leads to serious sight-threatening complications like vision loss and blindness for diabetic patients. It would be difficult to find the symptoms at the initial stages of Diabetic Retinopathy but finding it initially would help to take the necessary steps to protect our vision. We can control diabetic retinopathy by early detection of the disease, including more fiber content food in the diet, and taking proper medication which will help to prevent or delay vision loss. It would be recommended to take an eye examination at least once a year. Manual examination and proceedings of the diagnostic and analysis of fund us images to substantiate morphological changes in microaneurysms, exudates, blood vessels, haemorrhages, and macula are usually time-consuming and monotonous tasks. The results are varying depends on the doctor's analysis and the possibilities of human error. The system-based diagnostics and analysis with the help of well-versed algorithms give more accuracy and efficiency which will greatly assist eye doctors and make it easy for them and quick actions taken by medical practitioners.

**Keywords:** Diabetic Retinopathy, Machine learning, neural network, feature extraction, haemorrhages, exudates, classification, supervised learning, lesion, self-supervised learning, transformers, diabetes mellitus.





## INTRODUCTION

The natural inducement of insulin by the body regulates the body's sugar and glucose levels and maintains the equilibrium of the body. Diabetes is a disease that causes the body's capacity to regulate insulin naturally which will be induced high-level carbohydrate metabolism and will interrupt the equilibrium of the body. As a result of these, the body's blood glucose levels go up and also will reversely affect carbohydrate metabolism. High appetite and frequent urination all are the after-effects of diabetes and also lead to weakness of the body. Diabetic Retinopathy (DR) is one of the resultant diseases induced if the diabetic is left uncontrolled for a long time. Considering the facts, this is a severe and widely spread disease among diabetic patients. The impact of the illness rise with age and thus, middle-aged and older aged people with diabetes are vulnerable to Diabetic Retinopathy (Atwany *et al.*, 2022; Chen *et al.*, 2019)[16][27]. Diabetic Mellitus is one of the direct cause of Diabetic Retinopathy (DR) in which glucose levels increases which blocks the blood vessels of the eye resulting in swelling and leaking of fluids from the eye which will lead to severe eye injuries (Atwany *et al.*, 2022)[16]

.Laser treatment is now available for patients whose eye sights are at risk and thus can prevent complete blindness or impairment of vision for a long time. Being said these facts that, the complete restoration of vision like a normal person couldn't possible with the existing treatment methods, for a blind person caused by DR. DR detection is a time taken to process that sometimes will take years to identify the symptoms and also it's an annual process that requires the expertise of the examiner(s) by different detection methods and the evaluation of the digital color fundus photographs of the retina with various techniques. Hence, detecting the DR at early stages is important for giving the early treatment of Diabetic Retinopathy. By 2040, Diabetic Retinopathy (DR) (Abdel-Hamid *et al.*, 2022; Alam *et al.*, 2020) [1] [7] impacted around 200 million people out of 600 diabetic people as per prediction. In the early stages of DR, there are no symptoms for DR patients with DR and even in the middle stages as well it's hard to find the symptoms, which will lead to late treatment in its severe stages. By the World Health Organization (WHO), 77% of Diabetic Retinopathy patients affects by Diabetes Mellitus (DM) for about 20 – 25 years (Abdelsalam *et al.*, 2021; Chen *et al.*, 2021) [3], [30].

The main cause of DR is the unusual increase in glucose levels (Alghazo *et al.*, 2019) [9]. A high increase in blood sugar levels will harm the blood vessels of the retina and will result in the fattening and exuding of blood vessels. From time to time the blood vessels may have been closed or it may stop flowing blood and also will lead to the growth of abnormal blood vessels in the retina. These anomalous changes will result in damage to the retina completely. One of the main reasons for blindness is Diabetic Retinopathy. It is separated into two phases Non-Proliferative (NPDR) and Proliferative Diabetic Retinopathy (PDR) (Ali *et al.*, 2021)[10]. The early stage of Diabetic retinopathy is called Non-Proliferative (NPDR). It is subdivided into three categories. They are mild, moderate, and severe (Ali *et al.*, 2021; Atwany *et al.*, 2022)[10], [16]. The advanced stage of Diabetic Retinopathy is Proliferative (PDR) which will result in neovascularization. Neovascularization is the process of excessive growth of blood vessels in the retina. Blindness can be happened by the blemishing or bleeding from the retina due to the blood vessels of the retina growing abnormally (Coram *et al.*, 2016)[34]. The physician examines retinal images and identifies the appearance and shape of lesion types in DR detection. The identified lesions for the diagnostic are; Haemorrhages (HM), Microaneurysms (MA), and soft and hard exudates (EX) (Asif *et al.*, 2021; Embong *et al.*, 2022) [15] [35]. Fig (1) shows the differentiation between the Diabetic Retina from the normal retina.

1. Microaneurysms (MA) is the earliest visible manifestation of diabetic retinopathy. It looks like tiny red round dots (micro-dots) are scattered on the retina. It varies from 15  $\mu\text{m}$  to 60  $\mu\text{m}$  in diameter and are most common in the posterior pole (Asif *et al.*, 2021; Coram *et al.*, 2016)[15] [34].
2. Haemorrhages (HM) are large dots or blots on the retina with irregular margin sizes of upwards of 125  $\mu\text{m}$  (Asif *et al.*, 2021; Chen *et al.*, 2021)[15] [30].
3. Hard exudates are yellow spots on the retina due to the leakage of plasma (Chen *et al.*, 2022) [29].
4. Soft exudates occur in the swelling of nerve fibers and white ovals visible on the retina (Asif *et al.*, 2021) [15].





**Sabeena and Jeyakumar**

Microaneurysms and Haemorrhages appear as red lesions, and Hard and Soft exudates appear as bright lesions. Different phases of DR are shown in Figure (2).

**Survey Papers Review In Literature**

This section exhibits a comprehensive review of various papers related to diabetic retinopathy. Improving the overall appearance and increasing the contrast of the retinal image using the image enhancement method done by Chen *et al.*, (2020) [28] which has proposed the computation of entropy image with the fundus photograph's green component. The optic disc segmentation (Cheong *et al.*, 2019) [31] and pre-processing of improved blood vessels were done using the green component in the RGB retinal image. In the proposed method, the green component of the RGB image of the color fundus is extracted and enhanced the details using unsharp masking (Heisler *et al.*, 2020) [39]. Accuracy and Sensitivity can be improved using the green component of the entropy images. For better detection of Sensitivity, Accuracy and Specificity can be pre-processed by unmasked (UM). The inputs of the entropy images of grey and green component can be pre-processed by UM with the bi-channel CNN which will further advance the detection of referable DR. Asif *et al.*, (2021) [15] used a different Deep Learning (DL) based 3D convolution neural network (3D CNN) architecture for binary and multiclass (5 classes) classification. The above study is detailing the advantage of considering both spatial and temporal dimensions together and solving the problem using a 3D Domain. The two datasets used in the study validate the outputs during the experiments. TeleOphtais the primary dataset which is the fundus images database with microaneurysms and exudates lesions.

The data used in the primary dataset have 99 3D volumes of healthy subjects and 83 3D volumes of diseased classes and the above shows the presence of microaneurysms and exudates. The secondary datasets consist of Gaussian-filtered retina scan images and by using the second dataset we can detect the five stages of diabetic Retinopathy such as no, mild, moderate, severe, and proliferative. In the above system, two techniques are used for the enhancement of the dataset. They are Random shifting and random weak Gaussian blurred Augmentation. In this system, both datasets are normalized and have an intensity value that ranges between 0 and 255. For the above system, the data are mainly taken from the Kaggle dataset. Cai *et al.*, 2021 [23] proposed a model whose main aim was to differentiate between diabetic retinopathy and a healthy control by determining an OCTA image from 3\*3 mm scans using various machine learning models. In this model the OCTA angiography dataset (Le and Tan 2019; Back *et al.*, 1997; Shen *et al.*, 2017)[48] [18] [53] of superficial vascular plexus (SVP), a deep vascular Plexus (DVP), and a retinal vascular network (RVN) were taken from 19 Diabetic retinopathy patients and 25 Healthy control. For extracting the features from each image the system used a discrete wavelet transform. In this model for the classification of wavelet features four machine learning models such as the elastic net penalty (LR-EN), support vector machine (SVM), and XGBoost (the gradient boosting tree) were used. Among the four models, LR-EN or LR algorithm gives a powerful strategy for the ophthalmologist to recognize the early stages of diabetic retinopathy and it was implemented using the software glmnet. The Support Vector Machine and Extreme gradient Boosting models are done with the help of a support vector machine function in R Package 107 and the software XGBoost.

Using the above system the subtle retinal vascular alternations can be easily identified by OCTA images. The various methods used in the above system include (a) Setting Population after the detailed study and systematic design (b) segmentation of the OCTA images, and Acquisition (c) Data pre processing and OCTA extraction. During the analysis phase, patients with biased and serious diabetic retinopathy were not included. In this system, the thickness map of the intra-retinal and retinal angiography was not used. The system concluded that the LR-EN algorithm with the scanned OCTA angiography images (3 \* 3 mm) derived more accurate sensitivity and specificity values for the detection of Diabetic Retinopathy. Hietala *et al.*, 2019 [40] differentiate DR into 5 types and the classification of Macular Edema systems. The methods used are the Original fundus image dataset, Retinal image grading systems, and grade ability. In this system, the images are graded based on (i) the grading of the images (ii) the Diabetic Retinopathy types, and (ii) the Macular Edema. The images were graded with the proposed international clinical diabetic retinopathy standards and macular edema disease severity scales denoted as PIRC and PIMEC (Fang and Qiao, 2022) [36]. Three additional levels of grading system were obtained in PIRC and PIMEC grading, i.e.; (i) a binary system of non referable/referable diabetic retinopathy, (ii) a binary system of non referable/ referable diabetic





**Sabeena and Jeyakumar**

macular edema (Coram *et al.*, 2016; Baskaran *et al.*, 2017)[34] [20]. In this case, if the macular edema is absent it is defined as non-referable diabetic macular edema and referable if any level of macular edema is present. The images were resized into different pixels for easing the pre-processing steps. The evaluations of the trained models are done for NRDR/RDR on the Messidor dataset (Murugesan *et al.*, 2015) [51]. The Messidor dataset is designed and labeled for a 4-graded system grading for diabetic retinopathy and a 3-graded system grading for macular edema. The Messidor images having a grade >2 or the images having the risk of macular edema grade >1 are only considered for reference and other categories of images are not considered for reference and are non-referable images. Allassery *et al.*, 2021 [8], proposed the Identification of diabetic retinopathy through machine learning. The above study focused on patients who are examined and have a chance of getting diabetic retinopathy and whose retina scan is the focus. The above method used two image classifier algorithms first one is the OPF (optimum path first) and the second one is RBM (Restricted Boltzmann Machine). The above classification is done based on the existence or absence of disease-related retinopathy (DR). The two classifier algorithms take out around 500 to 1000 characteristics extracted from the images after the training phase for disease classification, identification of retinopathy, and normality patterns. The above system used four models for the classification of images. They are,

1. OPF-500: extracted 500 image features using the RBM algorithm and classified by the OPF algorithm
2. OPF-1000: extracted 1000 image features using the RBM algorithm and classified by the OPF algorithm
3. RBM-500: extracted 500 image features using the OPF algorithm and classified by the RBM algorithm
4. RBM-1000: extracted 1000 image features using the OPF algorithm and classified by the RBM algorithm

The systematic computational methodology with a non-open dataset uses five different Diabetic Retinopathy and macular edema classification systems to access its performance. The system executes a better result by using a deep neural network and is also used to correct the quality of retinal images through reprocessing [34] (Chen *et al.*, 2022) [29] proposed a new model named GCA (Global channel Attention mechanism). In the above system, the kernel size adaptive convolutional algorithm which is one-dimensional is used in the system based on the feature map of the dimensions. Also, a new model named GCA-Efficient NET (GENet) is designed for the Diabetic Retinopathy color image severity and is based on the transfer learning technique. The GCA model extracts the global channel correlation information of the feature map using two steps. In the first step, using adaptive one-dimensional convolution with small parameters derive the local inter-channel correlation. Then integration of the local inter-channel correlation will extract the global channel correlation as the second step. To avoid a large number of parameters with the fully connected operations, these two-step operations are very effective, so that the model avoids many over fitting problems which won't run into the complexities, and also the global channel correlation features extract it successfully. The Efficient Net concept is used to derive the deep convolution neural network model here and models are divided into 8 different categories from EfficientNet-B0 to B7 in the Efficient Net.

Treisman *et al.* [13] proposed the attention mechanism emphasizes the impact of a particular factor in the model after simulating the model's attention to many factors and giving weights to all the factors based on their merits based on the human brain's attention. Due to the success rate of this attention mechanism, this has been widely used in many deep learning methods such as sequence to sequence, localizing the image, understanding more about the image, and translating the lips. The transformation structure derived by the Machine Translation team of Google discards the recursion of the model and the convolution structures. To process the feature sequences, they used the simpler attention mechanism-based theory. Chen *et al.*, (2020) [28] developed a model integration of multi-scale CNNs for the classification of retinal images. This model is shallower when compared with the traditional approaches like CNN, LCNN, and VGG16noFC, and this system can improve the accuracy by 3% to 9%. Also, this is very helpful for the training samples as the lack of high-quality labelled training samples impacts the classification of the retina images and detection of retinopathy. Various vision features can sense by the Shallow CNN through the analysis of multiple receptive fields. A performance integration model of base learners, which is a shallow CNN is proposed. Multi-scale base learners based on 2-D entropy of images in sample distribution are also explored in this paper. A convolution neural network is composed of neurons that have learnable weight and biases (Jaderberg *et al.*, 2015) [43]), CNN consists of convolution layers interspersed with pooling layers, followed by fully connected layers as in a standard multilayer neural network (Jadoon *et al.*, 2019; Jaderberg *et al.*, 2015) [44] [43]. Based on the different parameters like



**Sabeena and Jeyakumar**

voting and mean, the performance integration model has more accuracy in comparison with other integration models. Also, the system with a performance integration model has more classification and gives more efficiency using small datasets compared with other approaches (Abdelsalam and Zahran, 2021)[3] proposed a novel approach for DR early detection based on the multifractal geometry had been proposed. Analysis of the macular OCTA images will help to detect and diagnose early Non-Proliferative Diabetic Retinopathy (NPDR).

To automate the diagnosis process with the help of the Support Vector Machine (SVM) and machine learning supervised algorithms which will improve the efficiency and accuracy of the result set. This approach will also help to identify the early stages of Diabetic Retinopathy as well as other Retinopathy diseases, which affects the blood vessels or neovascularization distribution system. The above system shows that for the early detection of retinal disease multi fractal analysis, tools will play a vital role. Finding out the non-proliferative Diabetic Retinopathy in the initial stage and also predicting the existence of Microaneurysms in the fund us image done by (Qiao *et al.*, 2020)[52] proposed that the starting stage of diabetic Retinopathy is the formation of macular edema and Microaneurysms in the retina. If we properly diagnose it at the right time we can avoid the risk of non-proliferated diabetic retinopathy. The above method encloses deep learning with a convolution neural network as the core component for finding out the presence of microaneurysms in fund us images, accelerated with GPU (Graphical processing unit). That will do the detection and segmentation of medical images with high performance and low latency inference. For identifying the features of microaneurysms the system used the semantic segmentation method that will divide the image pixel based on their common semantics.

In the paper, they have developed a new approach for detecting microaneurysms (MA), an unregulated classification approach with a sparse Principal Component Analysis. Any deviation from the standard microaneurysms is detected by statistical monitoring having the model that represents MA, and Principal Component Analysis which helps to find the concealed structure of microaneurysms data. (Alifet *et al.*, 2021) [10] proposed a model using a deep-learning ensemble approach to detect diabetic retinopathy. The above model was used for the training of five deep Convolution Neural Network models (Resnet50, Inception3 (Kang *et al.*, 2021) [45], Xception (Karsaz 2022) [46], Dense121 (K *et al.*, 2016)[47] and Dense169 (K *et al.*, 2016) [47]. A publicly available dataset named the Kaggle dataset is used for collecting the data. Using the above models, the system encrypts the features and upgrades the classification for different stages of Diabetic Retinopathy. Chandra Kumar and Kathirvel have introduced a new system and discussed the various stages of DR classification. Using the Kaggle dataset, DRIVE, and STARE datasets, the CNN model has been introduced in the system with a dropout regularization technique for the classification of the stages of DR. For the Augmentation and pre processing they use an editing tool and it is done manually. Here in this system (Annick *et al.*, 2020) [12], a high-end Graphics Processing Unit (GPU) is used for training the model and has used the NVIDIA CUDA DNN Library and 2a 880 CUDA core for the learning of the GPU. Also, the system used to learn the back-end library, the Ker as deep learning package with Tensor flow machine. (Fang and Qiao, 2022)[36] proposed a new model, using the DAG network with the multi-feature fusion of fundus image to classify the DR. In this model three important features of diabetic retinopathy such as haemorrhage, fund us neovascularization, and retinal varices are drawn out using distinct algorithms. The above features get off to a classification model based on a DAG network for understanding its multi-feature and feature learning. In the end, a fine-tuned model is used for recognizing and classifying of DR. In the above system, real hospital data and a dataset named DIARETDB1 are used (Treisman 1986) assessing the experimental results.

Arifet *et al.*, (2022) [14] proposed a new system which is used a hybrid neural network model of entropy enhancement for Diabetic Retinopathy detection. Here, the enhancement technique of novel entropy is used to address the issue, two images that represent the two different stages of DR look similar and hence make the diagnosis extraneous and error-prone. For this, the technique is devised by exploiting the discrete wavelet transform to improve the visibility of medical images by making the subtle features more prominent. Here, the system used three datasets namely Ultra-Wide Filed (UWF)(Jaderberg *et al.*, 2015)[43] Asia Pacific Tele Ophthalmology Society (APTOS), and MESSIDOR-2 for comparing the performance. The above system performed well in large datasets, and here APTOS is the relatively larger dataset compared to the other two MESSIDOR-2 and Ultra-Wide Filed (UWF). So the Entropy



**Sabeena and Jeyakumar**

enhancement technique performed well in APTOS. Liang *et al.*, (2018) [49] developed a system to classify the given set of fund us images through automation, and to detection of DR, convolution neural networks are used. Its hyper-parameter tuning joined with transfer learning volutes the new model. Here in this system some of the latest CNN models such as Alex Net, Vgg Net (Chung *et al.*, 2016) [33], Google Net, and Res Net are used to detect the DR and classify those categories. After the cross-validation, the VgNet model classification shows the highest accuracy. Table 1 shows the dataset that is used for DR detection training and classification of models. Table 2 shows a performance comparison of the review papers.

**CONCLUSION**

This paper review is based on the analysis of several papers that were collected from 56 research works and papers which were categorized in terms of various methods used to detect Diabetic Retinopathy (DR). Several studies used convolution neural networks and image-processing diagnosis techniques for detecting the severity of DR. The Diabetic Retinopathy classification is also based on several machine learning algorithms. The study is based on the various types of lesions such as Microaneurysms, Haemorrhages, and Soft and hard exudates find out in a diabetic retina, also based on the different stages of Diabetic Retinopathy (DR) such as trivial, moderate, severe, and proliferative. It includes training a model with a data set and validating it with a different testing set. Table.1, specifies some of the datasets mostly available to the public that is needed for the detection during the training and diabetic retinopathy model classifications. Table. 2, specifies the methods and techniques that are used for the performance calculation like Accuracy, sensitivity, specificity, and, precision, etc. The main issues find out is manual checking of Diabetic Retinopathy takes much more time and is a lengthy procedure for the ophthalmologist. Likewise, the limitations of the dataset restrict the fund us image variations that can be used in the assessment of indicators.

**Declaration of Competing Interest**

The authors declare that the information presented is as objective and unbiased as follows. Referenced papers that appeared in this paper are for only my review purpose of the research.

**Abbreviation**

DR, Diabetic Retinopathy; HC, Healthy Controls; LR, Logistic Regression; LREN, Logistic Regression Regularized with elastic net penalty; SVM, Support Vector Machine; XGBoost, Gradient Boosting Tree; OCTA, Optical Coherence Tomography Angiography; DVP, Deep Vascular Plexus; SVP, Superficial Vascular Plexus; RVN, Retinal Vascular Network; DLS, Deep Learning System; NRDME, Non-Referable Diabetic Vascular Edema; RDME, Referable Diabetic Macular Edema; NRDR, Non-Referable Diabetic Retinopathy; RDR, Referable Diabetic Retinopathy; AUC, Area Under the Curve; OPF, Optimum path First; RBM, Restricted Boltzmann Machine; GCA, Global Channel Attention Mechanism; GENet, GCA Efficient Net; KNN, K- Nearest Neighbour; SVM, Support Vector Machine; GPU, Graphics Processing Unit, MA, Microaneurysms; PM, Prognosis of Microaneurysms; PMNPDR, Prognosis of microaneurysms and early diagnosis system for non-pro life rative Diabetic Retinopathy; CNN, Convolution Neural Network; CuDNN, CUDA Deep Neural Network;

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## Sabeena and Jeyakumar

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**Table 1. Dataset is used for Diabetic Retinopathy (DR) detection training and classification of models.**

Paper ref	Data Set	Image Count	Image size (px)	Train+ Val/Test Size	DR Grading	Camera Used
[1]	Kaggle	35126	433*289 to 5184*3456		Yes	Digi Fund us camera
[12]	Kaggle	35126	3888*2951	64%,20%& 16%	Yes	Digi Fund us camera
[8]	Kaggle	35126	256*256	70%,30%	Yes	Digi Fund us camera
[3]	OCTA image[74] to [79]	114	3*3mm scans	-	Yes	Optovue OCTA device
[2]	TeleOphta, Kaggle	35126	210*210*12 512*512*2	-	Yes	
[13]	DIARETDB1 , Real hosp data		1500*1152 2992*2000	85%&15%	Yes	50-degree wide view
[16]	UWF [50] APTOS MESSIDOR-2[1]	1600 3662 1748		80%,10% ,10%	Yes	Varies varies 45-degree wide view
[6]	Kaggle	35126	224*224	80%& 20%	Yes	Fund us camera

**Table 2. Performance comparison of review papers**

Paper Ref	Accuracy	Sensitivity	Specificity	Precision	F1 score	AUC	Method used
1	87.83%	77.81%	93.8%	-	-	0.93	Bichannel convolution Neural network
3	0.82	0.84	0.80	-	-	0.84	Optical coherence Tomography Angiography images using ML
6	0.956	0.956	0.989	0.956	-		GENet based on GCA attention mechanism
7	76.5%	77.2%	93.3%	-	-		Random Forest Classifier
12	80.83	-	86.7	-	-		Deep Learning ensemble approach
15	95.68%	86.47%	97.43%	-	-	0.9786	Deep Convolution Neural Network
10	98.5	100	97.3	-	-		Multifractal + Support Vector Machine
13	98.7	-	100	100	98.9	-	DAG Network model
16	0.92	0.99	0.99	0.85	-	0.95	Entropy enhanced with Hybrid Neural Network





Sabeena and Jeyakumar



Fig 1: Difference between a Normal retina and Diabetic Retina

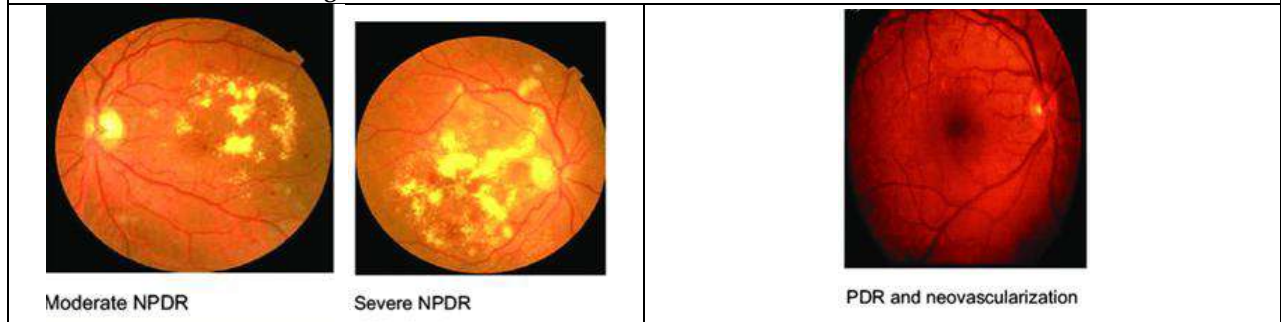


Figure 2. Different phases of Diabetic Retinopathy





## Data Mining Approach for the CRM Application in the Banking Domain

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### ABSTRACT

Customer Relationship Management" (CRM) is an important and commonly used Data mining application in the banking domain to interact with customers in proper and effective way. As banking is considered as a service industry, the purpose of maintaining a strong and effective CRM is a critical issue [1]. Data mining algorithms play a significant role in creating different types of models that can be used for the prediction of loan credibility behaviour of a customer. The approach is a step by step process that includes data collection, data preprocessing and the mining technique called classification. The data preprocessing involves different pre processing techniques especially feature selection. The loan credibility prediction is implemented by evaluating the classification accuracy. The data mining approach for the CRM application is demonstrated here using the credit data set. The classification models accuracy to identify behavior related to loan credibility is evaluated in this paper.

**Keywords:** Data preprocessing, Classification, CRM, Random Forest, Feature Selection

## INTRODUCTION

In this era, the most important application of data mining is "customer relationship management" (CRM). Customer relationship management deals with how a company interacts with its customers, both current and potential customers. Since banking is considered a service industry, maintaining strong and effective customer relationship management is critical [1]. CRM has become an integral part of banks in today's global complex environment [2]. The main areas where data mining tools can be used in banking are customer segmentation, bank profitability, credit evaluation and approval, marketing, fraud detection and cash management and forecasting functions [2]. Banks provide numerous credit options and loans., so it is quite common for customers to turn to banks for loans to fulfill their shopping needs. This practice has increased day by day especially in business, education, marriage and agriculture, but the downside is that many people take advantage and abuse the services provided by banks. Credit evaluation and approval processes are evident to understand the eligibility of a person or corporate entity. The main



**Soni P M and Anna Diana K M**

purpose of a bank is to lend money from various sources. Lending money to customers is very easy, but getting it back is a complicated process. The main objective of banks as lenders is thus to ensure profitability of sanctioned loans and advances. To maintain your CRM, give credit to trusted customers who can reasonably pay it back within the agreed time frame from trusted sources. Banks have a huge amount of customer transaction data every day. Data mining tools help analyze this data and turn it into information that are able to predict a customer's borrowing behavior. In banking domain CRM can be maintained by predicting the lending behavior of the customer. Data mining analyzes the huge data collected from banking transactions and finally aggregates it into meaningful information. This information helps the bankers to take the right decisions and leads to the smooth functioning of the organization. After formulating the problem, collect the relevant data and use some pre-processing techniques to transform the raw data into a suitable form for use in the mining process. Finally, use the data mining function, especially the classification, to classify the customer into two groups, such as those who can pay the loan amount quickly or not.

**LITERATURE REVIEW**

The literature survey includes the basic concept of data mining, different data mining techniques, the concept of classification, different classification algorithms and various feature selection methods.. H. Abdou *et.al* in [10] stated that loan officers took judgmental and subjective decisions based on their experience and analysis of data. C. R. Abrahams *et.al* in [11] stated that traditionally, decisions related to credit evaluation were made by banking officials based on past experiences, historical performances, and some of the measures of the credit especially character, capacity, capital, collateral, and conditions. Strahan *et.al* stated in [12] the lending business in Banks is too risky and hard. The borrower risk was affected by bank loans' price as well as non-price terms. Borrowers can be riskier borrowers, smaller borrowers, fewer cash borrowers, and borrowers pay higher interest rates on their loans. A. Mukherjee in [13] stated even though it is risky, granting several types of loans is an important service that provides more income to commercial banks and other lending organizations. In Classification process, an instance of the given dataset has to be classified into one of the target classes which are already known or defined [14,15]. According to L. C.Thomas, and J. N. Crook in [16,17] credit scoring has included both modern concept of mining the data and conventional statistical methodologies in recent years., such as Linear Discriminant Analysis (LDA), Logistic Regression(LR), Classification And Regression Tree (CART), Multivariate Adaptive Regression Splines (MARS), Expert System, Genetic Programming Model neural network, and its latest development Support Vector Machines (SVM). Wiginton J.C stated in [18] the method of logistic regression and discriminant analysis are the most broadly established statistical techniques used to classify applicants as "good" or "bad". In [19] Berson *et al* stated that Classification aims to map a data item into one of several predefined categorical classes. Feature selection is a dimensionality reduction technique that reduces the number of attributes to a manageable size for processing and analysis [20].

**Data Collection**

The data were collected from a UCI depository. The attributes are listed in Table -1

**Data Pre Processing**

It is possible for the client transaction data gathered from the banking domain to include noise, inconsistencies, missing values, or duplicates. This has an impact on the mining process' dependability. If the input data that the user collected are not perfect then they will not get the accurate results of the mining process that has been applied on this data [5]. Accurate results of data mining process can be obtained from high quality input data. So data preprocessing is mainly focused to improve the quality of data and consequently the mining results. Preprocessing data is a crucial stage in data mining which deals with preparation and transformation from the initial data set to the final data set[4]. The below mentioned categories of data pre processing are utilized to change initial data set to final data set.

1. Data cleaning
2. Data integration
3. Data transformation



**Soni P M and Anna Diana K M****4. Data reduction and Dimensionality reduction**

In computer science, data mining is a process for gleaning knowledge and patterns from massive amounts of data. To make sure the raw data is in an appropriate format for analysis, preprocessing is necessary before applying the modelling. Preprocessing data is a crucial stage in the data mining process that has a big impact on the final results' precision and effectiveness. The excel format has to be converted into respective formats (.csv,.arff) required for the processing of various data mining models. Data cleaning involves the processing of duplicate and missing values. A other calculated value, such as the mean, median, or mode, is used to manage the missing numbers. For example, all the missed "Jobs" in the dataset are swapped out for the term "Business" as it is the most occurred job. Label Encoding is a method for data transformation. It will convert labels in the credit data set into the numeric form in order to easily transformed into a machine-readable form. Data reduction is a method to reduce the volume of initial data set and should produce the same performance [5]. Feature selection is an important data reduction method. Feature selection has been shown to be beneficial in improving learning efficiency, raising predicting accuracy, and decreasing the complexity of learned results. [6,7] . Table 2 represents the accuracy obtained both prior to and following the feature selection procedure.

**Data Modelling**

Classification is used in scenarios where we need to identify the category or class into which a new observation might belong. Classification is among the data analysis methods that predict class labels [7]. There are more classification methods such as Statistical-based, Distance-based, Decision tree-based, Neural network-based, Rule-based [8]. Choosing the correct classification method thus becomes very important for obtaining accurate results. Random Forest is now known to be one of the most efficient classification methods [9]. In order to classify a customer as "eligible customer" or "not eligible customer" using credit dataset binary classification method is used. The process of classification divides the dataset into two parts , one for creating the model called training dataset and other for testing the model called testing dataset. ZeroR, Adaboost, JRip, SMO, Kstar,Random Forest, Ridor, and DTNB are the various classification algorithms that can be applied on the credit data set. The efficiency can be measured by evaluating the accuracy of each classifier. Kappa Statistic, and, Mean Absolute Error are also evaluated. These metrics are used to evaluate better classification algorithm for the loan credibility prediction. The classification performance based on the above measures is described in the table 3 and the implementation is demonstrated in the Figure 2. TheTable3 shows that the Random Forest classification algorithm produced better accuracy on the credit data set. The figure 3 represents the classification accuracy, figure 4 represents classification Kappa metric and figure 5 represents Classification MAE metric. From the above graphs ,it is clear that Random Forest algorithm can perform better for classifying the customer as "eligible customer " or "not eligible customer" for issuing the loan.

**About Technology**

Weka is a powerful tool for handling the operations of data mining such as data preparation, classification, regression, clustering, association rules mining, and visualization. . The graphical user interface (GUI) of Weka 5 makes working with data simple for both novice and expert users. Through its Java API, it also facilitates scripting and interaction with other computer languages, including R and Python. The numerous 29 operations that can be carried out in Weka are shown in figure 5. The process start with the raw data set and apply preprocessing tools to clean the raw data set into preprocessed dataset and it can be used for mining operations. The data mining algorithms were applied on this preprocessed dataset. The different data mining operations are **Classification**, **Clustering** and **Association Rule Mining**. Using the data preprocessing technique known as attributes selection, six features can be automatically chosen to produce a smaller dataset. Weka offers a number of data visualization tools for the model's statistical output. Moreover, many models can be used on the same dataset. As a result, WEKA causes data mining models to develop quickly overall.





**Soni P M and Anna Diana K M**

## CONCLUSION AND FUTURE SCOPE

The paper is concluded that the Customer Relationship Management application can be implemented using data mining approach. The data mining technique involved in the process is classification. The accuracy before and after data preprocessing method called feature selection is also examined. From the experiment it is clear that the classification algorithm Random Forest produced better accuracy after applying the feature selection methods. The future enhancement of the work can be applied to handle large amount of data using some big data technologies .

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**Soni P M and Anna Diana K M**

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**Table 1 – List of Attributes**

SI	Name of attribute
1	Checking_Status
2	Duration
3	Credit_History
4	Purpose
5	Credit_Amount
6	Savings_Status
7	Employment
8	Installment_Commitment
9	Personel_Status
10	Other_Parties
11	Residence_Since
12	Property_Magnitude
13	Age
14	Other_Payment_Plans
15	Housing
16	Existing_Credits
17	Job
18	Num_Dependents
19	Own_Telephone
20	Foreign_Worker
21	Class

**Table- 2: Performance metric of feature selection algorithms**

Classifiers	Accuracy (%) Before Feature Selection	Accuracy (%) After Feature Selection
Jrip	74.3	75.6
ZeroR	70	70
SMO	78.4	78.5
Adaboost	73.7	73.7
Random Forest	99	99.6
Ridor	76	78.3
DTNB	71.1	74.9

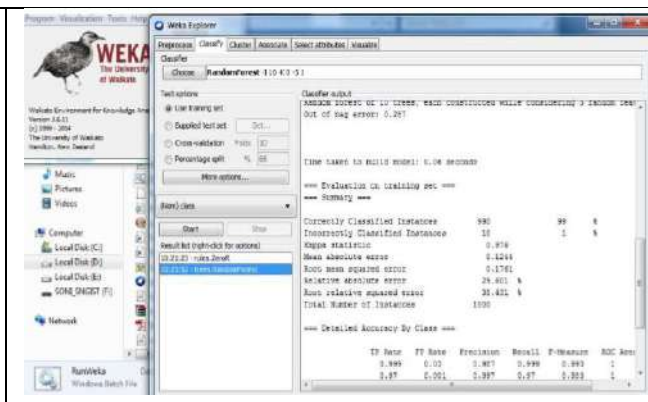
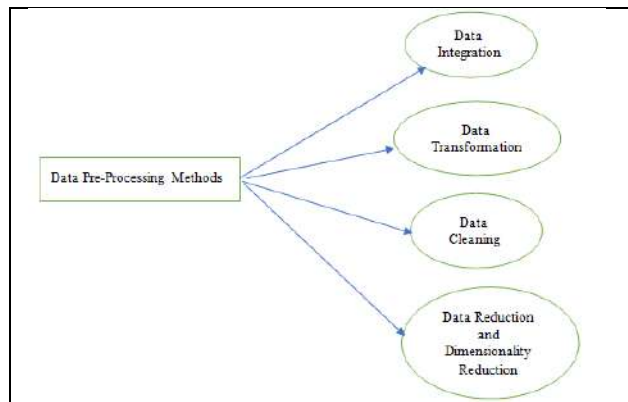




**Soni P M and Anna Diana K M**

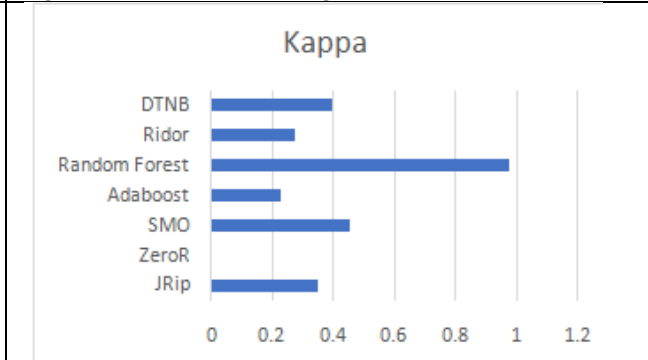
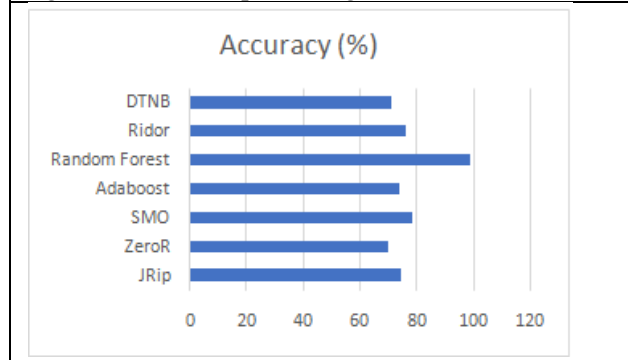
**Table 3: Classification Accuracy**

Classifiers	Accuracy (%)	Kappa	MAE
JRip	74.3	0.346	0.366
ZeroR	70	0	0.42
SMO	78.4	0.45	0.216
Adaboost	73.7	0.225	0.342
Random Forest	99	0.976	0.124
Ridor	76	0.2701	0.24
DTNB	71.1	0.394	0.362



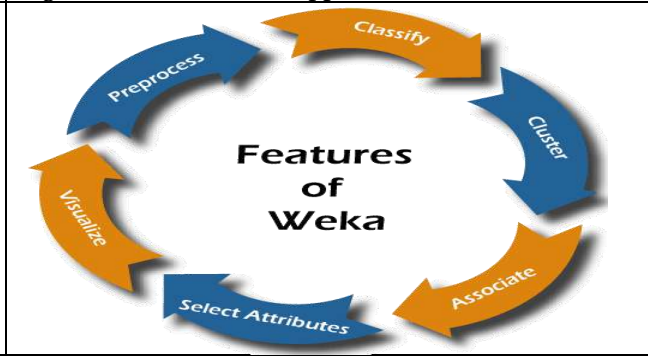
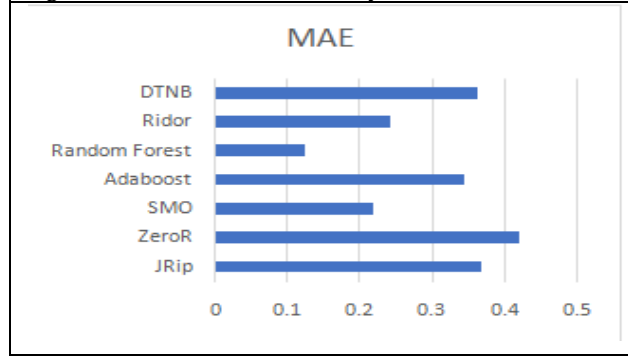
**Figure - 1: Data Pre-processing methods**

**Figure 2: Classification using Weka**



**Figure 3: Classification Accuracy**

**Figure 4: Classification Kappa metric**



**Figure 5: Classification MAE metric**

**Figure 6: Operations of Weka**





# Exploring the Effectiveness of Information Gain Method for Feature Selection in Designing Intrusion Detection Systems for IoT Security: A Comprehensive Literature Review

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## ABSTRACT

The growing number of IoT devices demands stronger security, with IDS as a key tool for protecting them. As more and more IoT devices connect, we need better security measures. IDS are crucial for keeping them safe. This research examines how effective Information Gain is at selecting features for IDS in IoT security, and reviews existing research on using Information Gain for feature selection in IoT-specific IDS. The review begins by contextualizing the significance of IoT security challenges and the role of IDS in mitigating emerging threats. A particular emphasis is placed on the importance of feature selection in optimizing IDS performance. The Information Gain Method is introduced as a key approach in this context, with an exploration of its principles and applications. Through an extensive examination of existing literature, including empirical studies and comparative analyses, this paper synthesizes key findings regarding the efficacy of the Information Gain Method. The review discusses insights gained from studies employing IGM in the design of IDS for IoT security and identifies trends, challenges, and areas for future research. By offering a comprehensive overview of the current state of research on this topic, this paper contributes to the understanding of how Information Gain can enhance feature selection strategies, thereby fortifying the development of effective IDS for IoT security.

**Keywords:** Internet of Things (IoT), Security, Intrusion Detection Systems (IDS), Feature Selection, Information Gain.



**Laiby Thomas and Anoop**

## INTRODUCTION

With the integration of diverse devices into networked systems, the Internet of Things (IoT) has experienced exponential expansion. IoT device proliferation has, however, also raised the possibility of security breaches and threats. By identifying and stopping hostile activity, intrusion detection systems (IDS) are essential for protecting Internet of Things environments. A crucial first step in improving the effectiveness and precision of IDS is feature selection [1]. Finding the most pertinent and instructive aspects from the large amount of accessible data is known as feature selection, and it is an essential stage in the creation of an efficient intrusion detection system. The Information Gain method has become well-known among feature selection strategies because it can quantify how important a given feature is to improving intrusion detection model accuracy [2]. The purpose of this thorough literature analysis is to investigate the usefulness of the Information Gain approach while choosing features for Intrusion Detection Systems that are especially made for Internet of Things security. We seek to offer a comprehensive overview of the most recent methods, difficulties, and developments in utilizing Information Gain to improve the effectiveness of IDS in IoT contexts by exploring the literature. IDS enables the early detection of possible security risks within IoT networks by offering real-time monitoring and detection capabilities. Early detection lessens the impact of assaults by enabling quick action and mitigation strategies [3]. IDS uses anomaly detection methods to find anomalies in IoT network traffic that deviate from typical patterns of activity. Finding abnormalities aids in identifying possible security lapses, such as malevolent acts, illegal access, or data theft [4]. IDS uses anomaly detection methods to find anomalies in IoT network traffic that deviate from typical patterns of activity.

Finding abnormalities aids in identifying possible security lapses, such as malevolent acts, illegal access, or data theft. Intrusion detection systems are designed to continually monitor network traffic and analyze behavioral patterns for abnormalities in real-time, enabling them to quickly identify and respond to security breaches [5]. Because they can detect and prevent tampering, unauthorized changes, and other actions that could compromise the general reliability and performance of networked devices, intrusion detection systems are essential to maintaining the integrity of Internet of Things systems[6]. Information gain approach combines as a viable feature selection solution for improving Intrusion Detection Systems (IDS) for Internet of Things (IoT) security. This machine learning-based method is especially applicable in the dynamic and heterogeneous Internet of Things context since it measures the decrease in uncertainty within a dataset when taking particular features into account. Information gain helps discover critical metrics necessary for detecting security risks in Internet of Things networks by ranking attributes that greatly reduce uncertainty [7]. This study investigates the efficacy of information gain in great detail with the goal of shedding light on its benefits and drawbacks via comparisons with other approaches, literature reviews, and experimental assessments. By means of this inquiry, the research aims to provide significant insights into the current discussion around enhancing the security of networked devices in the Internet of Things.

### Objectives

This study aims to comprehensively evaluate the information gain method's performance in the area of feature selection for intrusion detection systems (IDS) in Internet of Things (IoT) environments. The study is to investigate how information gain helps improve the performance of IDS by methodically assessing how good it is at choosing pertinent features, with a particular focus on IoT security. The goals of the study include a thorough analysis of how information gain affects the precision and effectiveness of IDS models used in Internet of Things networks. Additionally, the study aims to determine and examine any obstacles or restrictions related to the use of information gain in the context of IoT IDS feature selection. The creation of reliable and scalable intrusion detection systems (IDS) that are suited to the security problems of Internet of Things (IoT) environments is greatly advanced by this research. The diversity and heterogeneity of linked devices present never-before-seen security threats as IoT grows [8]. This work covers a crucial component of improving security measures by concentrating on the evaluation of the information gain method for feature selection in IoT IDS particular. It is hoped that the results would provide insightful information about how information gain might strengthen IoT networks against new threats. The design



**Laiby Thomas and Anoop**

and implementation of IDS can be greatly impacted by an understanding of how this strategy helps identify and prioritize pertinent characteristics in real-time monitoring.

**Related Work**

A lot of study has been done on the effectiveness of feature selection techniques in the design of intrusion detection systems (IDS) for Internet of Things security. This section offers a brief overview of the body of research that has already been done in the topic, emphasizing important studies and their significant contributions. Alazzam *et al.* [9] in their paper proposes a novel approach to binarize continuous optimization, which is compared to conventional methods for binarizing continuous swarm intelligent algorithms. It also introduces a wrapper feature selection algorithm for Intrusion Detection Systems (IDS), utilizing the Pigeon Inspired Optimizer. In another study, conducted by Balakrishnan *et al.* [10], contributes to the existing literature by introducing and implementing an Intrusion Detection System (IDS) designed for effective attack detection, thereby expanding the scholarly knowledge in this field. The primary novelty is the use of a brand-new feature selection technique to choose the ideal number of features from the KDD Cup dataset.

This algorithm is called the Optimal Feature Selection algorithm based on Information Gain Ratio. In their article, Nimbalkar *et al.* [11] presents a feature selection technique for Intrusion Detection Systems (IDSs) that ranks and finds the top 50% of characteristics for identifying DoS and DDoS attacks. Information Gain (IG) and Gain Ratio (GR) are used in this process. The suggested method uses union and insertion operations on subsets that are obtained from the highest-ranked IG and GR features. Using a JRip classifier, the approach is evaluated and validated on the IoT-BoT and KDD Cup 1999 datasets. Jaw *et al.* [12] in their work presents an ensemble classifier combined with a hybrid feature selection (HFS) strategy to improve intrusion detection system attack classification. In order to effectively pick subsets of features with high correlation, the suggested method makes use of the advantages of CfsSubsetEval, genetic search, and a rule-based engine. This lowers model complexity and enhances generalization. KODE (K-means, One-Class SVM, DBSCAN, and Expectation-Maximization) is an ensemble classifier that consistently distinguishes between malicious and normal cases based on their asymmetric probability distributions.

**Overview of Feature Selection in IDS**

In their research Alazzam *et al.* [13] uses the Pigeon-Inspired Optimizer (PIO) as the core optimization tool, the study suggests a wrapper feature selection technique for intrusion detection systems (IDS). One important contribution is the development of a new way to binarize the continuous PIO, which provides a different approach from the traditional methods in swarm intelligence algorithms. The effectiveness of this binarization methodology is assessed in the study by contrasting it with conventional techniques. The main goal is to improve the feature selection procedure for intrusion detection systems (IDS), and the study sheds light on the possible benefits of the suggested algorithm and binarization technique over current methods. By putting forth an enhanced Naive Bayes classifier, Kumar *et al.* [14] seeks to increase intrusion detection accuracy in IDS. Improving classification accuracy and cutting processing time in comparison to current classifiers are the main objectives.

The study uses three common feature selection techniques to improve the suggested classifier's performance and accuracy in evaluating network traffic in order to meet these goals. The emphasis on increasing accuracy as well as processing economy highlights how useful the research is for intrusion detection systems in real-world settings. The main goal of the study by Yiqun He *et al.* [15] is to identify and comprehend the major obstacles that Internet of Things (IoT)-based applications in high-risk Environmental, Health, and Safety (EHS) businesses must overcome in the context of Industry 4.0. To systematically identify these problems, the research combines a thorough literature analysis with a survey method. A total of 28 significant difficulties have been identified by the study, some of which include communication (c2) and energy efficiency (c1). This methodology enables a comprehensive analysis of the constraints encountered by IoT applications in EHS sectors, offering insightful solutions for resolving these issues within the framework of Industry 4.0. Sarhan *et al.* [16] performs a thorough analysis of well-known problems and



**Laiby Thomas and Anoop**

obstacles in the field of the Internet of Things (IoT), including topics such dependable collaboration, standards, protocols, operational issues, data management, and software difficulties. The study sheds light on the challenges faced by IoT implementations and covers a wide range of directions relevant to these concerns. The paper also emphasizes the contributions and ongoing work being done by several research communities to address these issues.

**Introduction to Information Gain**

To measure a feature's efficacy in terms of its capacity to distinguish and categorize data, machine learning and feature selection practitioners frequently employ the idea of information gain. When considering decision trees and other classification techniques, it is especially pertinent. Measuring the decrease in entropy or uncertainty brought about by including a certain feature into the decision-making process is the basic concept that drives information gain. The degree of disorder or unpredictability in a dataset is represented by entropy. By choosing features that maximize Information Gain, one seeks to improve the model's predictive power. Higher Information Gain features are considered more informative because they greatly lower uncertainty and enhance the model's overall predictive performance [17]. Information Gain serves as a crucial metric in the process of feature selection, evaluating and ranking features based on their ability to predict the performance of a model. Features with high Information Gain are preferred as they provide more valuable insights into the underlying patterns within the data. One can make more effective and efficient models by choosing features with the largest Information Gain, which reduces the dataset's dimensionality while preserving the most pertinent data for precise classification or prediction tasks. By concentrating on the most informative features, this increases interpretability in addition to improving model performance [18]. The following table presents a concise overview of past studies employing Information Gain (IG) across diverse domains such as natural language processing, healthcare, finance, and cyber security. A comparative understanding of the many uses and results of Information Gain in various study contexts is made easier by the formatted presentation.

**Information Gain in IoT Security**

Using Information Gain (IG) in the design of Intrusion Detection Systems (IDS) for Internet of Things (IoT) security is essential to improving threat identification and anomaly detection performance. IG is a useful feature selection metric in the context of IoT, where a multiplicity of linked devices continuously generate enormous volumes of data. IDS designers can optimize the system's performance by using IG to help them sort through the vast amount of data provided and choose the most relevant and instructive aspects [23]. Using IG in IDS design for IoT security entails evaluating how each feature affects the capacity to distinguish between benign and malevolent activity. High IG features are thought to be more informative and are therefore essential for efficiently identifying anomalies or intrusions. This methodology not only enhances the precision of the IDS but also aids in alleviating the difficulties brought about by the resource limitations frequently linked to IoT devices. By ensuring that the IDS concentrates on the most pertinent elements of the data stream, the implementation of IG enhances detection capabilities and improves overall safety in Internet of Things environments [24]. Alwahedi *et al.* [23] conducted a survey that offers a thorough analysis of how machine learning (ML) approaches might improve Internet of Things (IoT) security. The survey, which is divided into five categories, covers important facets of machine learning's role in IoT security. The writers provide a perceptive synopsis of current machine learning trends that are especially relevant to cyber threat identification in Internet of Things settings. The report also explores current cyber detection techniques, with thorough explanations of their definitions, methodologies, attack surface considerations, and assessments. One notable aspect of the survey is its thorough exploration of the ML techniques employed in IoT security, with a focus on defining and comparing their advantages and drawbacks within relevant use cases.

**Comparison with Other Methods**

Several feature selection techniques are used in data analysis and machine learning. These methods cater to different scenarios and considerations, and the choice often depends on the characteristics of the dataset, the specific learning algorithm used, and the desired outcomes of the analysis. Here's an overview of several popular methods:







Laiby Thomas and Anoop

## METHODOLOGY

Datasets used for evaluating machine-learning models in the context of IoT environments need to address specific characteristics unique to IoT. By considering these characteristics, datasets used for evaluating machine-learning models in IoT environments provide a more realistic and challenging testing ground, enabling researchers and practitioners to assess the models' effectiveness in addressing the complexities of IoT security. In their survey, De Keersmaecker *et al.* [25] presents a thorough and contemporary comparison of 44 IoT datasets, providing valuable insights for researchers seeking to evaluate machine learning techniques or design IoT security systems. The datasets were sourced from various platforms, including search engines and digital libraries like Google, IEEE Xplore, IEEE Data port, and Research Gate. The survey meticulously identifies general attributes of these datasets, emphasizing their diverse origins. While specific datasets for IoT security can vary based on the focus of the research, here are a few examples that are commonly used or suitable for evaluating machine learning models in IoT security scenarios:

### **CICIDS2017**

**Characteristics** A comprehensive dataset for intrusion detection in IoT environments.

**Details** It includes normal and attack traffic generated in a simulated IoT network, covering various attack scenarios and providing labeled data for supervised learning.

### **IoT-23**

**Characteristics** Focuses on diverse IoT devices and communication protocols.

**Details** It comprises network traffic data from 23 different IoT devices, allowing for the evaluation of models across a variety of IoT ecosystems.

### **Stratosphere IoT Dataset**

**Characteristics** Emphasizes real-world IoT network traffic.

**Details** Captures network traffic from a smart home environment, offering insights into the challenges of securing IoT devices in domestic settings.

### **Aarhus Smart Home Dataset**

**Characteristics** Captures IoT data from a residential smart home.

**Details** Includes sensor data from various devices, such as motion detectors and door/window sensors, providing a realistic representation of smart home IoT scenarios.

### **Bot-IoT Dataset**

**Characteristics** Focused on IoT botnet detection.

**Details** Contains network traffic data related to IoT devices infected with the Mirai malware, aiding in the development of models for botnet detection in IoT environments.

## **Recommendations for Future Research**

### **Future Directions**

#### **Machine Learning Advancements**

Advanced machine-learning techniques, such as deep learning, to improve the accuracy and robustness of IDS for detecting sophisticated and evolving threats.

#### **Context-Aware Intrusion Detection**

Context-aware IDS that consider the specific characteristics and context of IoT environments, adapting detection mechanisms based on the nature of connected devices and their interactions.

#### **Behavioral Analysis**

Behavioral analysis techniques to identify anomalies in the behavior of IoT devices, enabling the detection of novel and subtle attacks.

#### **Collaborative Intrusion Detection**

Collaborative approaches where multiple IDS instances share information and collaborate in real-time to enhance the overall security posture of IoT ecosystems.



**Laiby Thomas and Anoop****Explainable AI in IDS**

The integration of explainable artificial intelligence (XAI) techniques to provide transparent and interpretable insights into the decision-making process of IDS.

**Recommendations****Standardization of IoT Security Measures**

Standardized security measures and protocols for IoT devices, facilitating the development of more robust and interoperable IDS solutions.

**User Education and Awareness**

Emphasize the importance of user education and awareness programs to promote secure IoT device usage and discourage practices that may expose networks to vulnerabilities.

**Cross-Domain Collaboration**

Encourage collaboration between researchers, industry stakeholders, and policymakers to address security challenges comprehensively, considering both technical and regulatory aspects.

**Continuous Monitoring and Updates**

Establish a framework for continuous monitoring of IoT security threats and regular updates to IDS systems to address emerging risks and vulnerabilities.

**CONCLUSION**

As we conclude this literature review, it becomes evident that the exploration of Information Gain in the realm of feature selection for IoT security is both timely and transformative. The reviewed studies collectively reinforce the importance of selecting features judiciously to fortify intrusion detection capabilities in the ever-expanding landscape of IoT. Moving forward, it is imperative for researchers and practitioners to build upon these foundations, addressing the nuances of IoT security with a nuanced understanding of feature relevance. The synthesis of knowledge presented herein positions Information Gain as a cornerstone in the design and optimization of IDS, offering a pathway towards more resilient and adaptive security frameworks for the IoT.

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#### Introduction to Information Gain

Reference	Domain	Application	Key Findings
Bhandari <i>et al.</i> [19]	Healthcare	Disease Diagnosis and Prognosis	Used Information Gain to rank genetic markers for cancer.
Htet Htun <i>et al.</i> [20]	Finance	Stock Market Prediction	Applied Information Gain for feature selection in models.
Khraisat <i>et al.</i> [21]	Cyber security	Intrusion Detection Systems	Enhanced system performance through feature optimization.
Ramasamy <i>et al.</i> [22]	Natural Language	Sentiment Analysis	Identified salient linguistic features using Information Gain.





**Laiby Thomas and Anoop**

**Comparison with Other Methods**

Feature Selection Method	Overview	Advantages	Disadvantages
Filter Methods	Assess relevance based on statistics	Computationally efficient	Ignores feature dependencies
Wrapper Methods	Evaluate subsets through model training	Considers feature dependencies	Computationally expensive
Embedded Methods	Feature selection integrated in models	Efficient resource utilization	Limited to specific algorithms
Recursive Feature Elimination	Recursive removal of least important	Works well with various models	Computationally expensive, prone to over fit
Principal Component Analysis	Transform features into uncorrelated	Reduces dimensionality effectively	Loss of interpretability, assumes linearity
Information Gain	Measures feature relevance	Effective with non-linear relationships	Sensitive to noise in data
Genetic Algorithms	Evolutionary search for optimal subset	Handles complex interactions	Computationally intensive





# Advancing Towards a Secure and Sustainable Energy Economy- Insights from the State Energy and Climate Index of NITI Aayog

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## ABSTRACT

Energy stands out as a paramount catalyst for bolstering economies and upholding societal sustenance. Projections indicate a foreseeable surge in global energy consumption and concomitant carbon dioxide (CO<sub>2</sub>) emissions until 2050, propelled by factors such as burgeoning global population, heightened regional manufacturing activities, and elevated living standards (International Energy Outlook 2023). These parameters include Distribution Company's performance (DISCOM); Access, Affordability, and Reliability of Energy; Clean Energy initiatives; Energy Efficiency; Environmental Sustainability; and New Initiatives in the energy and Climate Sector. The comprehensive set of parameters encompasses 27 indicators. The final scores, presented in the last column of each table, are utilized for ranking states and UTs based on their performance in energy and climate action. The classification includes Front-runners, Achievers, and Aspirants, determined by the final score. A scrutiny of the performance of South Indian states, namely Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, and Kerala, reveals noteworthy trends. With respect to the Distribution Company's (DISCOM) performance, all states, with the exception of Telangana, have surpassed the national average.

**Keywords:** Energy, Company, Climate, economies, performance, states

## INTRODUCTION

Energy stands out as a paramount catalyst for bolstering economies and upholding societal sustenance. Projections indicate a foreseeable surge in global energy consumption and concomitant carbon dioxide (CO<sub>2</sub>) emissions until 2050, propelled by factors such as burgeoning global population, heightened regional manufacturing activities, and elevated living standards (International Energy Outlook 2023). Current global energy initiatives pivot on the dual objectives of extending access to modern energy universally while facilitating the transition towards cleaner energy sources, ultimately striving to achieve net-zero CO<sub>2</sub> emissions by 2050. The United Nations' 2030 Agenda for



**Sindhu and Santhosh**

Sustainable Development duly acknowledges the central role played by energy in effecting transformative change in human lives. In alignment with this recognition, the international community has embraced Sustainable Development Goal 7 (SDG7) as part of the broader set of 17 Sustainable Development Goals. SDG7 is committed to guaranteeing access to energy that is not only affordable and reliable but also sustainable and modern. The specific emphasis of this goal extends beyond mere energy access, advocating for improvements in the provision of clean and safe cooking fuels and technologies. Furthermore, SDG7 underscores the imperative of enhancing energy efficiency, amplifying the utilization of renewable energy sources, and promoting the widespread adoption of sustainable and modern energy solutions. These collective endeavours are geared towards realizing the overarching aspiration of ensuring comprehensive access to such energy services for all by the target year 2030.

**Energy and Climate Action-The Indian Scenario**

India assumes a pivotal role in the contemporary global energy landscape, as revealed by the India Energy Outlook 2021 presented in the International Energy Agency (IEA) Report. The report positions India as the third-largest primary energy consumer on a global scale, forecasting a substantial surge in energy demand in the coming years. Projections further indicate that India is poised to contribute significantly, accounting for 25% of the global energy demand growth over the next two decades. Concurrently, India stands as the third-largest emitter of greenhouse gases globally. In response to these challenges, the energy policy of the nation delineates two overarching objectives ensuring widespread access to affordable and reliable energy while concurrently mitigating reliance on fossil-based energy through an accelerated transition to cleaner alternatives. A significant articulation of India's commitment to addressing climate change transpired during the 26th session of the Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) in Glasgow. The Prime Minister elucidated India's strategic vision, encapsulated in five nectar elements referred to as the "Panchamrit" of India's climate action. These elements signify a comprehensive approach aimed at navigating the challenges posed by climate change (Ministry of Environment, Forest and Climate Change, (2022).

1. Achieving 500 GW of installed electricity capacity from non-fossil fuel sources by 2030,
2. Generating 50 per cent of its electricity requirements from renewable energy by 2030.
3. Reducing the total projected carbon emissions by an additional one billion tonnes
4. by 2030.
5. Decreasing the carbon intensity of its economy by less than 45 per cent by 2030, and
6. Attaining net-zero emissions by 2070.

India, being the most populous country with substantial projected growth potential, holds an important role in the global pursuit of clean energy transition and climate change mitigation. The nation is steadfast in its commitment to enhancing downstream delivery transmission, fortifying distribution infrastructure, improving the financial standing of distribution companies, ensuring widespread access to clean cooking fuel through efficient and affordable means, and guaranteeing a continuous 24x7 electricity supply. Achieving these objectives demands tailor-made policies that address the unique challenges and opportunities presented by the diverse geographical and economic characteristics of different states. Recognizing the impracticality of a one-size-fits-all approach across states, despite shared overarching goals, the government advocates for state-specific policies. A nuanced policy framework is deemed essential for each state, accounting for its distinctive characteristics. In pursuit of this, the government has undertaken the task of establishing benchmarks and assigning rankings to states. This stratagem aims to fine-tune the national energy and climate action policy, acknowledging and accommodating the diversities inherent in each state. To operationalize this approach, the NITI Aayog, in collaboration with the Bureau of Energy Efficiency (BEE) and the Alliance for an Energy-Efficient Economy (AEEE), has devised the State Energy & Climate Index (SECI). This index serves as a comprehensive tool to gauge and measure each state's initiatives and progress in improving the energy and climate sector. (State Energy and Climate Index, 2022). The overarching objectives of SECI encompass:

1. Ranking the States based on their efforts towards improving energy access, energy consumption, energy efficiency, and safeguarding the environment;
2. Helping drive the agenda of affordable, accessible, efficient and clean energy transition at the State level; and
3. Encouraging healthy competition among the states on different dimensions of energy and climate.





**Sindhu and Santhosh****Methodology and Data Source**

The research utilizes data from the State Energy and Climate Index (SECI) Round 1, released by NITI Aayog in 2022. To assess and compare the performance of States and Union Territories in the domain of energy and climate action, six parameters developed by NITI Aayog are employed. These parameters include Distribution Company's performance (DISCOM); Access, Affordability, and Reliability of Energy; Clean Energy initiatives; Energy Efficiency; Environmental Sustainability; and New Initiatives in the energy and Climate Sector. The comprehensive set of parameters encompasses 27 indicators. The composite score of the SECI is determined as the weighted mean of all the scores, with different weights assigned to each parameter, for each State/UT. The overall index score reflects the relative position of States/UTs in the SECI. Notably, DISCOMS, as a critical link in the entire energy value chain, are accorded higher weight age (40%) in the overall index. The remaining parameters, namely 'access, affordability & reliability of energy,' 'clean energy initiatives,' 'energy efficiency,' 'environmental sustainability,' and 'new initiatives,' carry weights of 15%, 15%, 6%, 12%, and 12%, respectively.

The distribution of weight age for each parameter is outlined in Table 1. The indicators are categorized into two groups: progressive indicators, where higher values indicate superior performance, and regressive indicators, where lower values signify better performance. Specifically, indicators 1.1, 1.2, 1.3, 1.4, 1.7, 1.8, 1.9, 2.4, 2.5, 4.1, and 5.1 are classified as regressive indicators (SECI,2022). The final SECI score is employed to rank the states and Union Territories (UTs). To enhance the comparability of performance in the energy and climate sector, states are categorized into three groups: larger states, smaller states, and Union Territories. The classification is based on the composite SECI score, facilitating a nuanced evaluation. States/UTs falling within the top one-third tier, possessing a composite SECI score greater than or equal to 46, are designated as "forerunners." Those within the range of 36 to 46 composite SECI score are termed as "achievers," representing the middle tier. Units with a composite SECI score below or equal to 36 are labelled as "aspirants," indicating the lower tier of performance. This classification framework provides a comprehensive understanding of the relative positions and achievements of states and UTs in the context of the SECI.

**DISCUSSION AND RESULTS**

This section undertakes a comprehensive analysis of diverse performance metrics across states and Union Territories (UTs) within the State Energy and Climate Index (SECI). The objective is to identify achievements and areas requiring improvement across various regions. Table 2, Table 3, and Table 4 provide the final SECI scores and parameter-wise scores for larger states, smaller states, and UTs, respectively. The final scores, presented in the last column of each table, are utilized for ranking states and UTs based on their performance in energy and climate action. The classification includes Front-runners, Achievers, and Aspirants, determined by the final score. An in-depth examination of the final SECI scores for larger states, as outlined in Table 2, highlights significant differentiations. Gujarat leads with a score of 50.1, followed by Kerala and Punjab, securing scores of 49.1 and 48.6, respectively. Chhattisgarh registers the lowest score in this analysis. Among the larger states, Gujarat, Kerala, Punjab, Haryana, Uttarakhand, and Maharashtra are designated as Front-runners. States categorized as Achievers encompass Himachal Pradesh (HP), Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, and Bihar. The remaining states fall within the Aspirants category. This nuanced breakdown aids in discerning the varying degrees of performance and achievements across states in the realm of energy and climate initiatives.

A scrutiny of the performance of South Indian states, namely Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, and Kerala, reveals noteworthy trends. With respect to the Distribution Company's (DISCOM) performance, all states, with the exception of Telangana, have surpassed the national average. In particular, in the Energy Efficiency parameter, all southern states have outperformed the national average. Tamil Nadu, in particular, stands out with an impressive score of 85.4 in this parameter, surpassing the national average of 29.1. Kerala emerges as a standout performer in the Access, Affordability, and Reliability domain, achieving a commendable score of 69.3. However, the



**Sindhu and Santhosh**

New Initiatives parameter presents a contrasting picture, with Southern states exhibiting suboptimal performance. Only Karnataka has managed to surpass the national average in this segment, indicating a notable disparity in the adoption of new initiatives among the Southern states. This nuanced analysis provides insights into the specific strengths and areas for improvement within the energy and climate performance of South Indian states. Despite being a high-performing state, Gujarat exhibits areas that necessitate improvement, particularly in the domains of New Initiatives and Energy Efficiency. Similarly, Kerala, while being commendable in its overall performance, could benefit from enhancements in the New Initiatives parameter. Notably, Himachal Pradesh, classified as an Achiever, stands out with exemplary performance, securing the highest scores in two parameters: Environmental Sustainability and New Initiatives. However, areas warranting improvement for Himachal Pradesh include Energy Efficiency and the performance of Distribution Companies (DISCOMS). This nuanced analysis underscores the need for targeted interventions in specific areas to further enhance the overall performance of these states.

The analysis of the State Energy and Climate Index (SECI) scores for smaller states and Union Territories (UTs) unveils distinct performance categories and noteworthy achievements. Within the realm of smaller states, Goa and Tripura emerge as Front-runners, showcasing remarkable accomplishments. Goa secures the highest score of 51.4, while Tripura excels in the New Initiatives parameter with an impressive score of 58.7. Manipur attains the Achiever designation, signifying commendable performance, while the remaining smaller states are categorized as Aspirants, indicating areas for potential improvement. An interesting trend among smaller states is evident, with average performance observed in Environmental Sustainability, where scores range from 55 to 40. Similarly, in Access, Affordability, and Reliability, scores fall within the range of 60 to 30. This commonality underscores areas where concerted efforts may be needed to enhance performance across smaller states, contributing to a more nuanced understanding of their strengths and areas for improvement in the context of energy and climate action. In the domain of Union Territories (UTs), Dadra and Nagar Haveli (D&N), Daman & Diu (D&D), Chandigarh, Delhi, and Puducherry have been distinguished as Fore-runners, showcasing commendable overall performance. In contrast, Jammu and Kashmir (J&K), Andaman and Nicobar (A&N), and Lakshadweep fall into the category of Aspirants, indicating areas for improvement. Insights into specific parameters highlight notable performance in DISCOM's Performance by four UTs, with Delhi being an exception. There is a general need for improvement in energy efficiency parameters across all UTs, except for Delhi. Additionally, Chandigarh, D&D/D&N, and Delhi demonstrate outstanding performance in Clean Energy Initiatives, boasting scores of 69.2, 68.6, and 67.6, respectively.

It is noteworthy that Chandigarh has surpassed the national average in all parameters, with the exception of Energy Efficiency. This detailed examination provides valuable insights into the unique strengths and areas for improvement within Union Territories in the context of energy and climate action. The country-level analysis of the average State Energy & Climate Index (SECI) score and individual parameter scores reveals substantial regional disparities in performance across different facets. Notably, the average score for New Initiatives stands at a modest 11.1, contrasting significantly with the considerably higher average score of 56.8 for Distribution Companies' (DISCOMs) performance. This marked difference underscores a significant gap in the national performance landscape, indicating a pressing need for substantial improvements at the state and Union Territory (UT) levels. The observed variation between the national average score and the lowest scores among states and UTs further accentuates the need for enhanced efforts. Particularly in parameters such as Clean Energy Initiatives, Energy Efficiency, and New Initiatives, notable advancements are essential for achieving a more balanced and sustainable energy and climate framework nationwide. This comprehensive analysis highlights key areas that require focused attention to bridge regional disparities and foster a more cohesive and effective national approach to energy and climate action.





**Sindhu and Santhosh**

**CONCLUSION**

The State Energy & Climate Index (SECI) has proven to be an effective tool in delineating the strengths and weaknesses of states and Union Territories (UTs) concerning diverse parameters representative of energy and climate action. One of its notable achievements is the documentation of best practices among peers, fostering a platform for states to draw inspiration from the successes of others. The SECI highlights critical areas for improvement, including the imperative for states to enhance their distribution infrastructure and systems, given prevalent challenges such as high Aggregate Technical and Commercial (AT&C) losses and intricate tariff structures. Noteworthy areas for enhancement encompass elevating per capita energy consumption, augmenting Compressed Natural Gas (CNG) vehicle penetration, refining last-mile connectivity, and ensuring the availability of clean energy sources for cooking. The report underscores the substantial distance yet to be covered by most states and UTs in terms of the Energy Efficiency parameter, stressing the importance of achieving low energy intensity and emission intensity for the realization of an energy-efficient economy. Furthermore, the SECI identifies that half of the states fall below the national average in terms of environmental sustainability and New Initiatives, emphasizing the necessity for concerted efforts and shared responsibility between central and state governments to facilitate effective energy transition and realize India's climate action objectives.

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**Table 1: SECI Parameters, Indicators & Weightage**

SL. NO.	PARAMETERS	INDICATORS	Weight age
1	DISCOM's Performance (weight age 40)	1.1. Debt Equity Ratio*	5
		1.2 Aggregate Technical & Commercial Losses *	7
		1.3. Transmission& Distribution Losses*	5
		1.4. Average Cost of Supply-Average Revenue Realized gap*	7
		1.5. Implementation of Time of Day/Time of Use Tariff for Consumers	2.5
		1.6. States Implemented Direct Benefit Transfer	2.5
		1.7. Open Access Surcharge Null *	5
		1.8. Regulatory Assets *	3
		1.9. Complexity of Tariff *	3
2	Access, Affordability and Reliability of energy (weight age 15)	2.1. Per capita energy consumption	4
		2.2. Hours of Electricity Supplied (Industry)	1.5





**Sindhu and Santhosh**

		2.3. Hours of Electricity Supplied (Agriculture)	1.5
		2.4. Cross-Subsidization*	5
		2.5. Life-line electricity and tariff *	3
3	Clean Energy Initiatives (weight age 15)	3.1. Clean Cooking Fuel Supply	5
		3.2. Renewable Energy Penetration	5
		3.3.CNG Vehicle Penetration	5
4	Energy Efficiency (weight age 6)	4.1. Energy Intensity of Gross State Domestic Product*	2
		4.2. Energy Savings in Commercial & Public Buildings	2
		4.3. Industrial Energy Savings	2
5	Environmental Sustainability (weight age 12)	5.1. Emission Intensity of Gross State Domestic Product*	4
		5.2. Utilization of RE Potential	2
		5.3. Percentage Change in Forest Cover	4
		5.4. Forest Carbon Stock	2
6	New Initiatives (weight age 12)	6.1. Electric Vehicle Penetration	4
		6.2. Availability of Charging Infrastructure for Electric Mobility	4
		6.3. Proportion of Consumers with Smart Meters	4

Source: State Energy & Climate Index Round-I, NITI Ayog, 2022 \*Regressive indicators

**Table 2: Performance of Large States in SECI Round -1**

Rank	States	DISCOM's performance	Access, affordability & reliability	Clean energy initiatives	Energy Efficiency	Environment sustainability	New initiatives	Score
1	Gujarat	72.7 (2)	52.4 (7)	39.2 (2)	40.1 (9)	35.1 (10)	5.5 (12)	50.1
2	Kerala	64.4 (6)	67.3 (1)	21.5 (7)	58 (4)	46.9 (3)	7.7 (9)	49.1
3	Punjab	77.1(1)	46.8 (10)	26.1 (5)	35.1 (12)	37 (8)	2.3 (17)	48.6
4	Haryana	69.8 (3)	53.6 (6)	42.9 (1)	11.7 (18)	33.4 (14)	6.9 (11)	47.9
5	Uttarakhand	61.9 (7)	55.3 (5)	18.5 (9)	50.5 (6)	48.7 (2)	14.7 (4)	46.5
6	Maharashtra	57.7 (13)	51.2 (9)	34 (3)	75.7 (2)	36.2 (9)	10.4 (6)	46
7	Himachal Pradesh	57 (15)	56.3 (4)	14.3 (12)	20.1 (16)	52.1 (1)	38.1 (1)	45.4
8	Karnataka	56.8 (16)	45.5 (13)	27 (4)	57.2 (5)	41.7 (4)	14.5 (5)	43.8
9	Tamil Nadu	57.3 (14)	46.3 (12)	21.7 (6)	85.4 (1)	39.2 (7)	4 (15)	43.4
10	Assam	67.3 (4)	38.3 (19)	4.3 (18)	39 (11)	39.9 (6)	17.6 (3)	42.6
11	Telangana	55 (18)	60.4 (2)	18.55 (8)	64.7 (3)	34.6 (12)	0.4 (19)	41.9
12	Andhra Pradesh	65.1 (5)	42.6 (18)	16.9 (10)	40 (10)	35 (11)	0 (20)	41.6





**Sindhu and Santhosh**

13	Uttar Pradesh	59.9 (9)	37.8 (20)	12.6 (13)	42 (8)	30.9 (16)	27.4 (2)	41
14	West Bengal	55.3 (17)	52 (8)	8.5 (14)	27.7 (13)	40.9 (5)	9 (8)	38.9
15	Bihar	61.3 (8)	45 (15)	4.9 (16)	22.8 (14)	33.7 (13)	7.6 (10)	38.3
16	Odisha	59 (10)	57.4 (3)	4.8 (17)	21.8 (15)	22.6 (18)	0.9 (18)	37.1
17	Rajasthan	49.2 (20)	42.9 (16)	15.5 (11)	44 (7)	31.4 (15)	4.8 (13)	35.4
18	Jharkhand	58.3 (12)	46.5 (11)	2.9 (19)	17.2 (17)	19 (19)	9.3 (7)	35.2
19	Madhya Pradesh	53.7 (19)	42.7 (17)	6.2 (15)	8.3 (19)	24.1 (17)	3.3 (16)	32.6
20	Chhattisgarh	58.4 (11)	45.4 (14)	2.1 (20)	0 (20)	5.8 (20)	4.2 (14)	31.7

Source: State Energy & Climate Index Round-I (2022), NITI Ayog

**Table 3: Performance of Small States in SECI Round -1**

Rank	States	DISCOM's performance	Access, affordability & reliability	Clean energy initiatives	Energy Efficiency	Environment sustainability	New initiatives	Score
1	Goa	63.4 (1)	59.6 (1)	62.4 (1)	16.6 (7)	43.7 (2)	12.4 (2)	51.4
2	Tripura	57.3 (3)	33.1 (6)	22.9 (2)	31.7 (2)	39.6 (5)	58.7 (1)	45
3	Manipur	57.6 (2)	34.1 (5)	4.7 (7)	22.1 (5)	41.3 (3)	7.3 (3)	36
4	Mizoram	51.7 (4)	39.3 (3)	18.99 (3)	29.7 (3)	38.2 (7)	1.1 (6)	35.9
5	Sikkim	43.2 (6)	37.6 (4)	13.8 (4)	33.3 (1)	25.2 (8)	0.6 (8)	33.3
6	Meghalaya	47.9 (5)	30.9 (8)	1.9 (8)	4 (8)	39.8 (6)	2.8 (5)	29.4
7	Nagaland	35.9 (7)	32.9 (7)	12.2 (5)	26.4 (4)	40 (4)	3.4 (4)	27.9
8	Arunachal Pradesh	31.1 (8)	43.2 (2)	5.8 (6)	19.8 (6)	49 (1)	1.1 (7)	27

Source: State Energy & Climate Index Round-I (2022), NITI Ayog

**Table 4: Performance of Union Territories in SECI Round -1**

Rank	Union Territories	DISCOM's performance	Access, affordability & reliability	Clean energy initiatives	Energy Efficiency	Environment sustainability	New initiatives	Score
1	Chandigarh	65.6 (4)	58.7 (2)	69.2 (1)	16.2 (2)	62.5 (1)	14.1 (3)	55.7
2	Delhi	66.2 (3)	38.3 (5)	67.2 (3)	43.9 (1)	38.6 (5)	49.7 (1)	55.6
3	D&D and D&N	71.5 (1)	60.3 (1)	68.6 (2)	0 (6)	36 (6)	7.9 (4)	53.2
4	Puducherry	67.9 (2)	57.7 (3)	20.3 (6)	0.6 (5)	42.7 (4)	37.9 (2)	48.5
5	Andaman & Nicobar	37.7 (6)	35 (6)	20.6 (5)	1.3 (4)	49.5 (3)	0 (6)	29.4
6	Jammu & Kashmir	31.2 (7)	51.4 (4)	11.6 (7)	9.9 (3)	51.8 (2)	4.5 (5)	29.3
7	Lakshadweep	42.9 (5)	25.9 (7)	33.6 (4)	0 (7)	7.1 (7)	0 (7)	26.9

Source: State Energy & Climate Index Round-I (2022), NITI Ayog





**Sindhu and Santhosh**

**Table 5: Average score, Highest score and Lowest score SECI- All India Comparison**

	<b>Average Score</b>	<b>Highest Score</b>	<b>Lowest Score</b>
<b>SECI score</b>	40.6	55.7 (Chandigarh)	26.9 (Lakshadweep)
<b>DISCOMS's performance</b>	56.8	77.1 (Punjab)	31.1 (Arunachal Pradesh)
<b>Access, Affordability &amp; Reliability</b>	46.4	67.3 (Kerala)	25.9 (Lakshadweep)
<b>Clean Energy Initiatives</b>	22.2	69.2 (Chandigarh)	1.9 (Meghalaya)
<b>Energy Efficiency</b>	29.1	85.4 (Tamil Nadu)	0.0 (Lakshadweep)
<b>Environmental Sustainability</b>	37.7	62.5 (Chandigarh)	5.8 (Chhattisgarh)
<b>New Initiatives</b>	11.1	58.7 (Tripura)	0.0 (Andhra Pradesh, A&N))

Source: State Energy & Climate Index Round-I (2022), NITI Ayog







## Algebraic Properties of Graph Theory and Its Applications

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### ABSTRACT

Mathematics heavily relies on graph theory. wherein the algebraic techniques used to solve graph theory problems serve as the foundation for algebraic graph theory. An effective framework for comprehending complicated systems and their behavior is provided by the relationships between graph properties and algebraic structures. There are two basic analogies between mathematics and graph theory. These originate from the adjacency matrix and automorphism group of a graph, two algebraic objects connected with the graph. The topic of graph analysis in relation to algebra and its uses is covered in this article.

**Keywords:** Graph, Group, Cycle, Subgroup, Connectedness

## INTRODUCTION

Graphs are mathematical structures that are used to depict pair wise interactions between objects. A graph's study is known as graph theory. A graph is composed of an array of edges, or connections, that join pairs of vertices, and a group of nodes, or vertices. Numerous characteristics of graphs, including connectedness, pathways, cycles, colorings, and much more, are investigated by graph theory. It is widely applicable in many domains, including social network analysis, operations research, computer science, and many more. Group theory, on the other hand, is the mathematical analysis of symmetry. It works with groups, which are algebraic structures made up of an operation satisfying specific conditions on a grouping of components. Group theory has applications in physics, chemistry, cryptography, and other fields. It is used to investigate the symmetries and transformations of mathematical objects. Studying the symmetries and algebraic characteristics of graphs is a common task at the





### Shajitha and Stinphy Maxon

interface between group theory and graph theory. Through the use of group theory tools, this connection facilitates a deeper understanding of the structural and symmetry aspects of graphs and offers insights into a variety of graph theoretic issues.

#### Fundamentals of Graph Theory

A set  $G = G(V, E)$  is a graph made up of two parts:

1. the finite set of vertices, also known as points or nodes, and
2. the finite set of edges, also known as lines or arcs, that connect two pairs of vertices.

**Directed graph** When each edge in a graph must have a direction assigned to it, the graph is referred to as a directed graph or digraph

**Walk** When an edge appears just once, a walk is a series of vertices and edges that starts at  $v_i$  and moves along edges to  $v_j$ . If a walk has the potential to start and finish at the same vertices,  $v_i = v_j$ , it is said to be a closed walk. If not, the stroll is said to be open.

**Path** It involves walking over a succession of vertices,  $v_0, v_1, v_2, \dots, v_n$ , with each vertex next to the one before it, without any vertex repetition. A path's length is determined by how many edges it has.

**Trail or simple path** A path without a repeating edge connecting a vertex  $(u)$  to  $v$  is called a trail or simple path.

**Circuit or Cycle** It is a non-zero length closed walk with the same start and finish vertices and no duplicated edges.

**Connected graph** If there is a path connecting each pair of vertices in a graph, it is referred to as connected; if not, it is considered unconnected.

**Sub graphs** A sub graph of  $G$  is defined as the graph  $H(V', E')$  that results from removing a small number of vertices and edges from  $G(V, E)$ , regardless of whether  $G$  is directed or undirected.

**Spanning sub graph** If a sub graph  $H(V', E')$  of a given directed or undirected graph  $G(V, E)$  contains every vertex in  $G$ , then  $H$  is called a spanning sub graph of  $G$ .

**Complete graph** A directed graph with two unique edges connecting each pair of distinct vertices is called a complete digraph.

**Regular graph** If the degree of each vertex in graph  $G$  is the same, then the graph is considered regular. A graph is referred to be a "k-regular graph" if each vertex has a degree of "k". In both the graphs, all the vertices have degree 2. They are called 2-Regular Graphs.

#### Bipartite graph

A basic graph If every edge of  $G = (V, E)$  connects a vertex in  $V_1$  to a vertex in  $V_2$ , then  $G = (V, E)$  with vertex partition  $V = \{V_1, V_2\}$  is referred to as a bipartite graph. A bipartite graph with partition " $G$ ," where  $G = (V, E)$ ,  $V = \{V_1, V_2\}$  is said to be a **complete bipartite** graph if every vertex in  $V_1$  is connected to every vertex of  $V_2$

#### Euler graph

The Eulerian path of a graph is a path that visits each edge exactly once. An Eulerian path with the same vertex at both is referred to as an Eulerian circuit. A graph with an Euler tour within it is called an Eulerian graph

#### Hamiltonian graphs

If every vertex in the connected graph is visited precisely once by a closed walk that exists there. If a graph has all of its edges repeated (apart from the starting vertex), it is referred to as a Hamiltonian graph.

#### Adjacency Matrix

The adjacency matrix, also known as the connection matrix, is a matrix made up of rows and columns that is used to show a straightforward labelled graph. It determines whether or not  $V_i$  and  $V_j$  are adjacent by assigning a value of 0 or 1 to their respective positions. It is a compact representation of the finite graph of a  $m \times m$  matrix  $M$  with  $n$  vertices.

#### Fundamentals of Group theory

Group theory is a fundamental area of mathematics that studies the algebraic structures known as groups. A group is a set  $G$  with a binary operation  $\circ$  that satisfies key properties: associativity, identity, and inverses.





### Shajitha and Stinphy Maxon

1. for all  $g, h, k \in G$ ,  $(g \circ h) \circ k = g \circ (h \circ k)$  (associative law);
2. there exists an element  $1 \in G$  (the identity) such that  $1 \circ g = g \circ 1 = g$  for all  $g \in G$ ;
3. for each  $g \in G$ , there is an element  $g^{-1} \in G$  (the inverse of  $g$ ) such that  $g \circ g^{-1} = g^{-1} \circ g = 1$ .

#### Abelian group

If a group  $\langle G, \cdot \rangle$  satisfies the following extra property, it is called abelian, or commutative  
Commutativity  $a \cdot b = b \cdot a$  for each  $a, b \in G$ .

#### Subgroup

Subgroups are subsets of a group that come together to form a group when subjected to the same action. They are essential to the study of groups, and a greater knowledge of group theory requires a grasp of their properties. Any subset  $H$  of  $G$  such that  $H$  is also a group with regard to the same operation is called a subgroup  $H$  of a group  $\langle G, \cdot \rangle$ .

#### Group Homomorphism

A map  $\Phi: G \rightarrow G'$  between two groups  $(G, \circ)$  and  $(G', *)$  is called a group homomorphism if the group operation is preserved in the following sense:

$$\Phi(a \circ b) = \Phi(a) * \Phi(b) \quad \forall a, b \in G$$

#### Group Isomorphism

An isomorphism is a map  $\Phi: (G, \circ) \rightarrow (G', *)$  between two groups if and only if the following criteria are met:

1. The homomorphism  $\Phi$  is a group; that is,  $\Phi(ab) = \Phi(a)\Phi(b) \quad \forall a, b \in G$ .
2.  $\Phi$  is upon and one-to-one.

An isomorphism is a bijective group homomorphism between groups.

#### Automorphism

For a group  $(G, +)$ , a mapping  $f: G \rightarrow G$  is called auto morphism if

1.  $f$  is one-one.
2.  $f$  is homomorphic i.e.  $f(a + b) = f(a) + f(b) \quad \forall a, b \in G$ .

#### Cyclic Group

If there is an element  $a^n$  in  $G$  such that  $a$  generates  $G$ , then a group  $(G, \circ)$  is said to be cyclic. Put differently,  $G = \{a^n : n \in \mathbb{Z}\}$ . The generator of  $G$  is the element  $a$ . It is expressed mathematically as follows:  $G$  is equal to  $\langle a \rangle$ . We have  $G = \{na : n \in \mathbb{Z}\}$  if  $G$  is an additive cyclic group formed by  $a$ .

#### Permutation Group

Given a set  $A$ , a permutation of  $A$  is a function  $f: A \rightarrow A$  which is 1-1 and onto. A permutation that come together to form a group under function composition is known as a permutation group of  $A$ .

#### Study of Algebraic Graph

The two main areas of overlap between graph theory and algebra are as follows. These originate from two algebraic objects connected to a graph: its auto morphism group and adjacency matrix. Any set of permutation matrices that commute with the adjacency matrix is known as the auto morphism group. Nonetheless, group theory and linear algebra are two distinct algebraic methods used in the two links. Mathematically speaking, linear algebra focuses on linear functions and equations, and how matrices and vector spaces are used to represent them. The foundation of linear algebra in contemporary geometry presentations. Mathematicians who study group theory might learn about algebraic structures known as groups. Many aspects of algebra have been influenced by the group theory approach. Both lie groups and linear algebraic groups are subfields of group theory that Two areas of group theory that have made progress are linear algebraic groups and lie groups. Graph theory is the study of graphs, which are





### Shajitha and Stinphy Maxon

mathematical structures that show pair wise interactions between objects. In this sense, a network consists of vertices, nodes, or points connected by arcs, lines, or edges. Graphs are among the most important things.

#### Applications of Algebraic Graph theory

An essential tool for studying electrical networks, from tiny integrated circuits to massive power systems on a continental scale, is algebraic graph theory. Conversely, early electrical circuit analysts established many of the essential findings of algebraic graph theory. The applications span various fields including computer science- network analysis, coding theory, Physics- quantum mechanics, Electrical networks and social sciences- sociology, communication networks.

#### Network Analysis

Network analysis and algebraic graph theory are closely linked subjects. Network analysis focuses on comprehending the structure and behavior of networks, while algebraic graph theory use algebraic techniques to explore the features of graphs. The representation of graph and network analysis using matrix algebra is a key link between the two. For instance, a graph's adjacency matrix's applications are possible to examine its characteristics, and matrix operations can provide details about a network's connectedness and organization. Furthermore, the characteristics and connectedness of graphs are studied by spectral graph theory, a subfield of algebraic graph theory, through the use of the mathematical eigen values and eigenvectors associated with graphs. Understanding connectivity, robustness and information flow in various networks like social networks, the internet or transportation systems.

#### Coding Theory

Algebraic graph theory and coding share multiple connections. The application of algebraic structures in coding theory is one significant point of linkage. For instance, the features of graphs representing error-correcting codes, which are employed in communication systems to securely transmit data over noisy channels, is amenable to analyse an algebraic graph theory. Furthermore, the features of graphs utilized in coding theory can be examined using methods from algebraic graph theory, such as spectral graph theory. This can aid in the design of effective error-correcting codes additionally the comprehension of their functionality. All things considered, algebraic graph theory offers a mathematical framework for comprehending the connections between graphs and codes and can be an effective tool for coding scheme analysis and design. Designing error correcting codes crucial in data transmission and storage, where graphs represents code structures.

#### Quantum Mechanics

Quantum graph theory is a subfield of mathematics that connects algebraic graph theory and quantum mechanics. In this discipline, the behaviour of quantum systems that is able to be shown as graphs is studied via algebraic approaches. In this application, graphs are mathematical structures that symbolize networks of connections between different points; in quantum mechanics, they can be utilized to model physical systems. Through the use of algebraic methods, scientists may examine the characteristics of these quantum systems and learn more about how particles behave, what energy states exist, and other significant aspects of quantum mechanics. All things considered, algebraic graph theory and quantum mechanics are related because they both employ mathematical techniques to characterize and comprehend intricate systems at the quantum level. Investigating quantum states through graph-based representations of interactions and entanglements.

#### Electrical networks

The study of electrical networks, the theory of graphs, and the accompanying matrices have a long and rich history of mutual evolution and synergy. Analyzing and modeling electrical circuits have inspired the creation and development of a wide variety of graph-theoretical notions and specific classes of matrices, beginning with the foundational Gustav Kirchoff's classical composition. Conversely, key developments in the theory of electrical networks have been made possible by algebraic graph theory notions and structures.





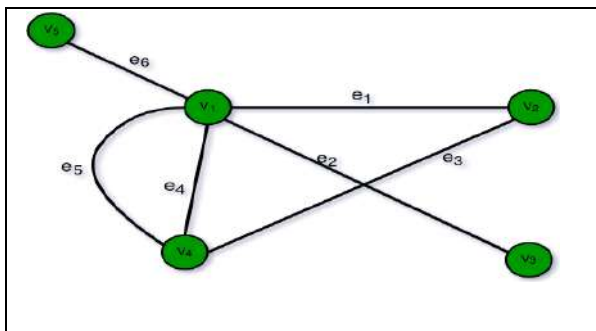
**Shajitha and Stinphy Maxon**

**CONCLUSION**

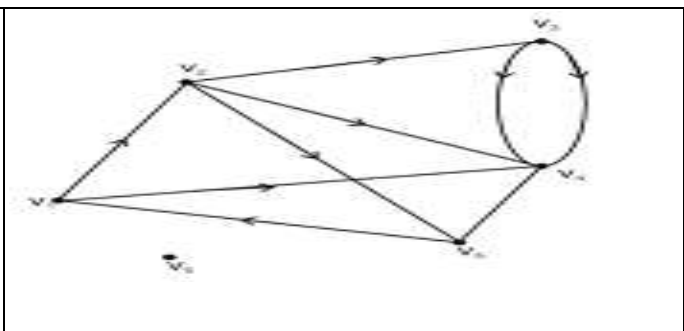
This work analyzes the literature for the study of algebraic theory in graph theory, utilizing the ideas and applications of the first three branches of algebraic theory. A few research works based on algebraic theory were also looked at in order to perform more research on the topic within algebraic graph theory. With applications in computer science, quantum mechanics, electrical networks, network analysis, sociology, and coding theory, algebraic graph theory is a flexible and potent tool. The profound relationships that exist between graph attributes and algebraic structures provide important new perspectives on the dynamic and structural features of complex systems. As multidisciplinary research and technology progress, algebraic graph theory continues to be an essential foundation for comprehending and improving a wide range of real-world systems.

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**Fig 1: Graph**

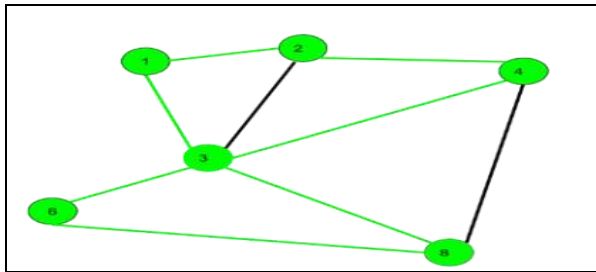


**Fig 2: Directed Graph**

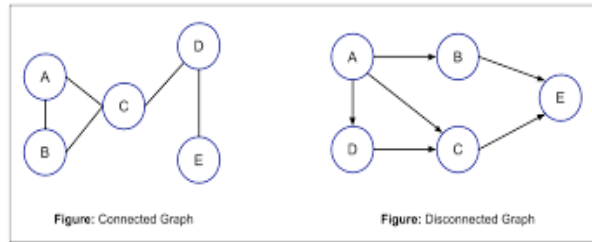




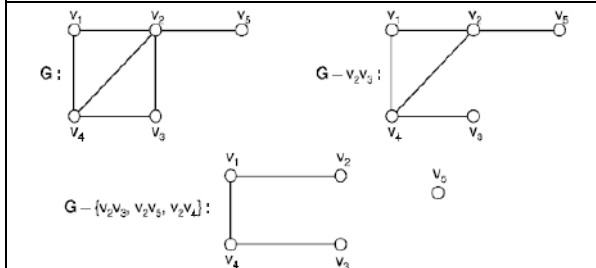
**Shajitha and Stinphy Maxon**



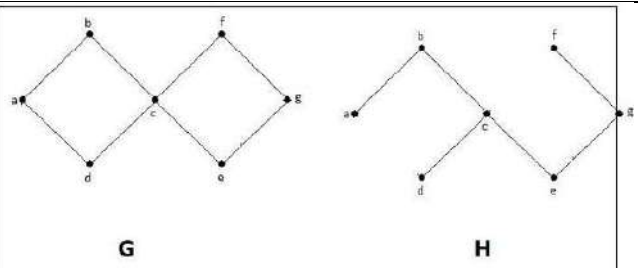
**Fig 3: Walk**



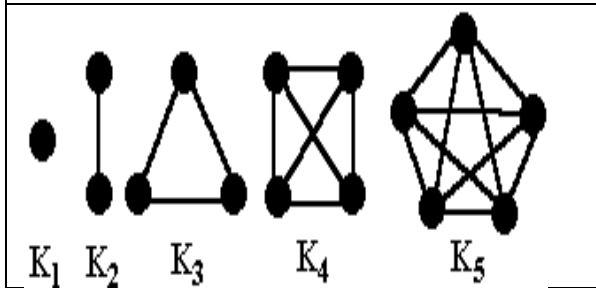
**Fig 4: Disconnected Graph**



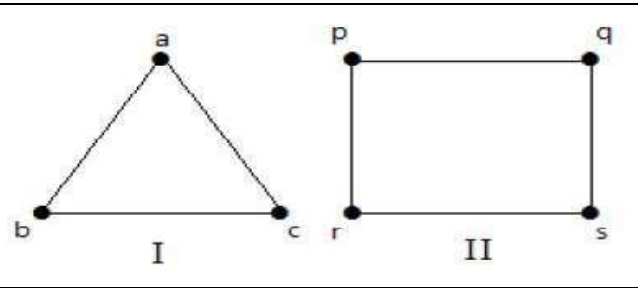
**Fig 5: Sub graph Graph**



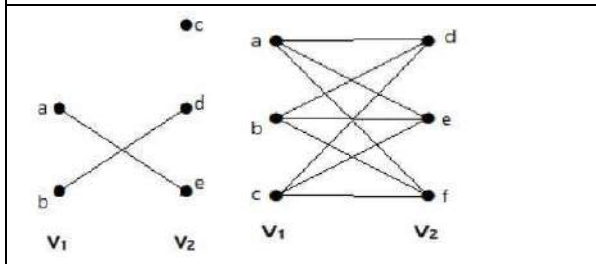
**Fig 6: Spanning sub graph**



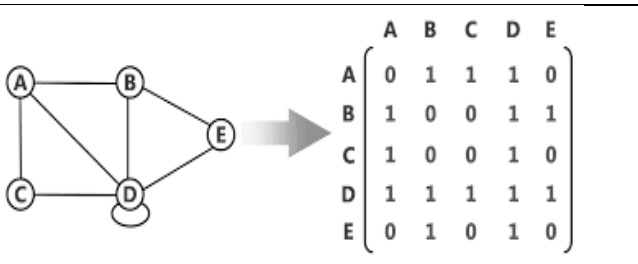
**Fig 7: Complete Graph**



**Fig 8: Regular Graph**



**Fig 9: Bipartite Graph**



**Fig 10: Adjacency Matrix**







## An IoT based crypto lock model using AES-128 and SHA-512

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### ABSTRACT

Cryptography is one of the current techniques which is used in secure communication systems. In any communication device encryption is a prominent factor. While transferring user information strong cryptographic encryption is required. In this proposed model, AES-128 is the crucial encryption method used for data. Also SHA- 512 is in cooperation for improving the security of user credentials. As an advancement, IoT can be used for user verification and latency in results. IoT is becoming one of the common techniques used in the communication system, with the help of such technology encryption can be done without exposing to any unauthorized third parties. With the combination of the above technologies and encryption techniques, the dominant crypto lock system is introduced. The performance of the proposed system is analyzed by using two communication protocols, MQTT and HTTP.

**Keywords:** AES, Cryptography, IoT, Servomotor

### INTRODUCTION

Most of the currently existing door locks use bio-metric, RFID,OTP, etc. However, none of them provide a complete solution in terms of complete physical security, easy remote access and securing information over the network. The proposed system is a highly secure door lock system named crypto Lock which is using three emerging fields of the modern era. That is an embedded system, IoT, and information security. Muhammad Ahtsham *et.al*, [1] proposed system gives an IoT revolutionizing the world. One of its renowned applications may be a smart door lock system to guard the property and secrets behind the door. In an IoT based system the user is transmitting his confidential data over the network which can contain passwords and other information, which are as crucial because of the secrets or



**Livin P Wilson**

valuables behind the door. To resolve the property security and knowledge security issues, uniquely propose a password-based and cryptographically shielded highly secure door lock system. To develop an entire system using cryptographic algorithms for secure communication and control unauthorized access. This lock not only protects our valuables behind the door but also protects our data which is being transmitted over the network. It gives easy remote access, controls unauthorized access and provides an entire sense of security. Md. Maksudur Rahman et.al, [2] In a system that implements a password protected electronic lock that features a superb profit over a typical lock, also as great security. The system comprises an input device and a 16\*2 alphanumeric display at the side of a PIC 18F452 micro controller. This state is notified by the alphanumeric display to the user. The user will perform operations like gap and shutting the lock, changing the current password through keypad instruction. This project aims to form such a variety of locks which will guarantee security also as price economical implementation. The lock is opened and only the right password is inserted. On the other hand, Password dynamic choice is somehow a lot of security that only an authorized person can do. While changing a password a fixed security code (known to the licensed person) at the side of the recent password is needed. Thus the improved security of the system is ensured.

An electronic lock allows the activation of an electrical appliance only on entering the right password. Here presented such an associate electronic lockup system during which a PIC18F452 microcontroller plays the role of the processing unit. The MCU is in interfaced with a 4 \* 4 matrix keypad and a 16 \* 2 LCD to the user interface [6]. It can be used as an associated electronic door lock by interfacing the output of the circuit with an electrically actuated door lock. R. Divya *et.al*, [3] proposed system gives an overall idea of various door lock access control mechanisms. Mechanical Lock System, before the arrival of modern electronic locking systems, locks were mechanically made using levers, gears, and wheels. These locks are fitted to the doors. These have two parts: key and lock. These systems are easily broken by the burglars. Password Security in door locks is nowadays a major concern all over the world. Behind the door, lie our valuable assets and confidential data. Various electronic locks are currently available within the market supported Password, RFTD, Biometrics, OTP, Cryptography, Wireless, and IoT. Every system has its own ad-vantages and disadvantages where one system overcomes the limitations of others. Each system along with its pros and cons has been analyzed and surveyed. As per our survey, each system is suitable for different application areas. Since technologies are developing rapidly the techniques of theft are also increasing. So an advanced door locking security system should be developed by combining the existing security techniques or by introducing a new technique that can solve all the drawbacks of the existing systems and this new system should be powerful, smart and unbreakable. J.Johnson et.al [4], An intelligent door lock system is provided with a position sensing device configured to be coupled to a drive shaft of a locking device.

The position sensor senses the position of the drive shaft and controls the locking device. An engine is provided with a memory coupled to the positioning sensing device. A circuit is coupled to the engine and an energy source is coupled to the circuit. A device converts energy into energy and is coupled to the circuit, positioning sensing device and therefore the drive shaft. Neelam Maj gaonkar et.al, [5] projected to utilize the various electronic elements out there within the market Associate in Nursing build an integrated home security system by victimization Bluetooth device and Microcontroller technology . This system gives service at a low cost compared to the cost of the available security system. To make a system that will provide twenty-four into seven services by exploiting registered password during this system able to unlock the door by that it will increase the safety level to forestall associate degree unauthorized unlocking. If the user forgets the combination of password this system gives the flexibility to the user to change or reset the password . Security live is incredibly high as provided in 2 ways. First, enter a password for blue-tooth connection and second is for unlocking the door in the application. Both passwords can be changed as and when required. This automatic password-based lock system can provide the user safer and low-value manner of the locking-unlocking system. Various control systems have been designed over the years to stop access to unauthorized users. It is therefore important to have a convenient way of achieving this goal. Automatic door system became a typical feature on many various sorts of buildings and houses. And they are getting popular every day to develop an efficient electronic device which give security. Home security has been a major issue because of the increase in crime rate and everybody wants 10 take proper action to prevent unauthorized users. There was a necessity to automate home in order that users can cash in on the GSM technology and computer



**Livin P Wilson**

system. The devices, sort of a telephone land line or the worldwide System of Mobile communication (GSM) can provide features which may be used domestically.

**SYSTEM DESIGN AND METHODOLOGY****Proposed System Design**

The overall control is done by the Raspberry Pi based single board computer. There are mainly 9 blocks working in a connected manner to achieve the required output. The IoT based door locks are safer, provide easy and remote access and control unauthorized access. In this digital world, network security is a critical issue facing these days. Maintaining data confidentiality and integrity is essential. IoT devices exchange very important information of users over the network. IoT is used to monitor the door lock using a smart phone over the network. When the client communicates with the server, the data can be sniffed or altered by unauthorized persons as a result of cyber-attacks. To prevent this, proper mechanisms for confidentiality and integrity are adopted. In this work, the AES- 128 algorithm is used for encryption and SHA-512 is used to provide authentication.

**Cryptographic Algorithms: AES-128 and SHA- 512**

AES-128 bit algorithm has generated fixed length value encryption, which takes 128 bits of hash text and performs ten rounds. It is a highly secure algorithm which is very resistant to brute force attacks. As the key size of the AES128 algorithm is 128 bit so there could be 2128 unique combinations. If make a brute force attack as shown in Table 2.1. AES-128 has less encryption latency. The SHA-512 algorithm generates a fixed output from a message which is called hash code. To generate the hash code, first of all, padding is done with plain text and then a 128 bit of original data is also appended to make the whole length as a multiple of 1024. After 80 processing rounds, a 512- bit hash is generated. A crypto lock has two security steps while transmitting data over the network. The first is data hashing to maintain the integrity of data to avoid reply attack and the second step is data encryption to maintain data confidentiality. The crypto locks get the information from the environment which contains Lock Id, door status, PIR reading, and user information. It then makes an array of this information in the form of plain text. The SHA-512 algorithm applied to this plaintext to generate a fixed-length output which is called hash code. To generate the hash code first of all padding is done with plain text and then a 128bit of original data is also appended to make the whole length a multiple of 1024. After that, the buffer is initialized and processed each block of plaintext in 80 rounds which generates a 512-bit output. After generating a fixed-length hash, encryption is done using the AES-128 bit algorithm, which takes 128 bits of hash text and performs ten rounds. In each round the key size is 128 bits (4 words or 16 bytes). There are a total of 44 sub keys used in 10 rounds. (40 sub keys in 10 rounds and four sub keys in the pre calculation round). Each sub key size is 32 bit. The encryption is performed on a 512-bit fixed-length value, and it is then transmitted over the network.

**MQTT and HTTP Communication Protocols**

MQTT is a lightweight message transport protocol. Since this protocol is extremely lightweight and bandwidth-efficient, it's best suitable for IoT applications with different wireless sensor network communications that are involved. It follows the publisher- subscriber model that is entirely different from the HTTP protocol's Request/Response model. One of the key features of MQTT is that it's an asynchronous protocol. The client need not be connected with the broker for the operation. In the publisher-subscriber model, the clients do not connect directly, instead, they are connected through a broker. The communication between publisher and subscribers aren't directly either and therefore the broker acts as a communication link between clients. Clients send messages by specifying a topic. This model ensures that both subscribers and clients need not be connected all the time and directly to each other, which enhances the security of each client. MQTT may be a binary-based protocol and has command and command acknowledgment format. So whenever a client sends a command to the broker, the broker sends an acknowledgment. This communication protocol is predicated on the TCP/ P protocol. So first there'll be a TCP connection establishment then there will be MQTT connection establishment then the info transfer will occur. After which TCP connection is going to be terminated. this is often a command and command acknowledgment based





### Livin P Wilson

protocol, for every function the client must send commands to the broker. and that they are sent as packets. when a client has got to publish a message following steps are made

1. The client has got to establish a connection to the broker by sending a connect packet (With username and password if needed)
2. Await the acknowledgment to ascertain if the connection is accomplished or if there's a mistake.
3. The client will send a publish packet that can contain the subject name and message to be published.
4. Await the publish response packet counting on the QoS level.
  - 0: There won't be any response.
  - 1: PUBACK - Publish an acknowledgment response.
  - 2: Await for PUBREC - Publish received.
  - Remit back PUBREL - Publish release.
  - Await for PUBCOMP - Publish complete.
5. If the communication is complete. The client can disconnect from the broker by sending a disconnect packet.

Similarly for subscribing to a topic

1. Send a Connect packet to the broker (With username and password if needed)
2. Await the Connect acknowledgment packet from the broker to ascertain if the connection is accomplished or if there's a mistake.
3. And when Connect acknowledgment is received, send the subscribe packet with the acceptable topic name.
4. Await the subscribe acknowledgment packet.

HTTP is a request-response protocol for client-server computing and not always optimized for mobile devices. There are 3 levels of quality of services: a best-effort delivery, a message that is going to be delivered a minimum of once. But the message can also be delivered more than once and each message is received only once by the counterpart.

### Block Diagram

The overall control of the system is done by the Raspberry Pi based single board computer. Figure 2.2 shows a basic layout of the block diagram. The various blocks in the block diagram are Microcontroller, Servo motor, PIR Sensor, Buzzer, LCD display, Keypad, LED, ESP 8266 and Power supply.

### Description of Block Diagram

#### Hardware Design

The servo motor has the main part in the activation of the door lock system. That is, lock and unlock the door lock. If someone tries to enter the room without entering the password (or from a backdoor), the PIR sensor will detect the unauthorized passage and a security alarm will be activated. A 16\*2 LCD is placed for a display of lock status. The lock system takes input from a smart phone via the internet. A WiFi module ESP 8266 is used to communicate over the internet. The crypto lock webpage for controlling and monitoring crypto lock hardware. And it communicates with hardware using ESP 8266.

#### Crypto Lock Website Design

A crypto lock webpage has been developed to contact with crypto lock. The webpage architecture has been shown in Figure 3.3. The webpage has two stages. Login stage and validation stage. In the validation stage, the user can log in to the webpage using a password and username through the Login interface. The server analyzes the username and password and validates the user. Then the user can access the lock operations and communicate with the hardware. Now the user can request to crypto lock for opening and closing of the door and resetting the password. The user sends encrypted and authenticated data using AES-128 and SHA-512 algorithms.

#### Server Design

The server is a necessary part of the complete crypto lock system. The server design is shown in Figure 2.4. It handles all databases, which can help in the seamless connectivity of future crypto lock.



**Livin P Wilson****Hardware Requirements**

It consists of Raspberry Pi based single board computer, HDMI interface, Servo motor, PIR sensor, ESP 8266, Keypad, Buzzer, LCD display and LEDs.

**Software Requirements****Raspbian OS**

Raspbian is an operating system (OS) designed specifically for the Raspberry Pi, a series of single-board computers. Based on the Debian Linux distribution, it is optimized for the ARM architecture, which powers the Raspberry Pi's processors. The OS features a user-friendly interface suitable for both beginners and experienced users, with a graphical user interface (GUI) and support for various applications. It is known for its optimized performance on the limited resources of the Raspberry Pi, ensuring a smooth user experience. Raspbian provides access to a comprehensive repository of pre-compiled software packages, facilitating easy installation and updates. With support for GPIO pins, it allows users to interface with external hardware, making it popular for educational and DIY projects. Raspbian, now rebranded as Raspberry Pi OS, continues to receive regular updates, ensuring users have access to the latest features, security patches, and software enhancements. Its educational focus has contributed to its widespread adoption in schools and learning environments.

**Python IDLE**

Python IDLE (Integrated Development and Learning Environment) is an integrated development environment bundled with the Python programming language. It features a graphical user interface with a code editor that supports syntax highlighting, indentation, and code completion. The interactive shells within IDLE allow users to run Python commands and test code snippets in real-time. IDLE also includes a debugger for step-by-step code analysis, breakpoint setting, and variable inspection during runtime. Integrated help provides easy access to Python documentation, aiding developers in learning and referencing Python features. Available on multiple platforms, including Windows, macOS, and Linux, Python IDLE caters to a diverse user base. It is often used in educational settings due to its simplicity and suitability for beginners learning Python programming. Users can customize the appearance and behavior of Python IDLE, including theme changes, keyboard shortcut configurations, and other settings. While IDLE is well-suited for smaller projects and beginners, more advanced developers may choose other integrated development environments (IDEs) with additional features and capabilities. Popular alternatives include PyCharm, Visual Studio Code, and Jupyter Notebooks.

**Arduino IDE**

The Arduino IDE (Integrated Development Environment) is a software platform designed for programming and uploading code to Arduino microcontrollers. It provides a user-friendly interface for writing, compiling, and uploading code to Arduino boards. The IDE includes a code editor with features like syntax highlighting and auto-completion to facilitate the development process. Additionally, it supports a variety of libraries and examples to help users get started with their Arduino projects. One of the key features of the Arduino IDE is its simplicity, making it accessible to beginners and hobbyists. It streamlines the process of writing and uploading code to Arduino boards, allowing users to focus on their projects rather than complex configuration. The Arduino IDE also includes a Serial Monitor, which enables communication between the Arduino board and the computer, making it easier to debug and monitor the behavior of the code. It supports a range of Arduino boards, making it versatile for different hardware configurations. Furthermore, the Arduino IDE is an open-source tool, allowing users to contribute to its development and customize it according to their needs. This openness has led to a supportive community and a wealth of resources available to Arduino enthusiasts.

**Description of flowchart**

Entering the password, security parameters will be activated and servomotor will lock the door. The client enters the right password and the door will be opened using the rotation of the servo motor. If an unauthorized person guesses the password as an incorrect attempt, the security alarm will be activated and notification will be sent to the





**Livin P Wilson**

authorized person. If a burglar tries to enter the room using a backdoor without using a password, the PIR sensor detects the unauthorized entry and activates the security alarm, then also notification is given to the user.

**CONCLUSION**

The proposed system designs a novel IoT based crypto lock for intelligent buildings or a smart home. AES-128 and SHA-512 are cryptographic algorithms that provide for better data security over the lock system. This IoT based system is available anywhere in the world. The motion sensors continuously monitor any unauthorized passage from the backdoor. The crypto lock webpage communicates with the system through a secure channel and gets updates. Crypto lock uses different secure cryptographic algorithms to protect our data over the network. MQTT is a data-centric and publish/subscribe model. Publish/ subscribe model provides clients with an independent existing from one another and increase the reliability of the whole system. Hence the crypto lock system with MQTT protocol provides high speed which is essential for communication systems.

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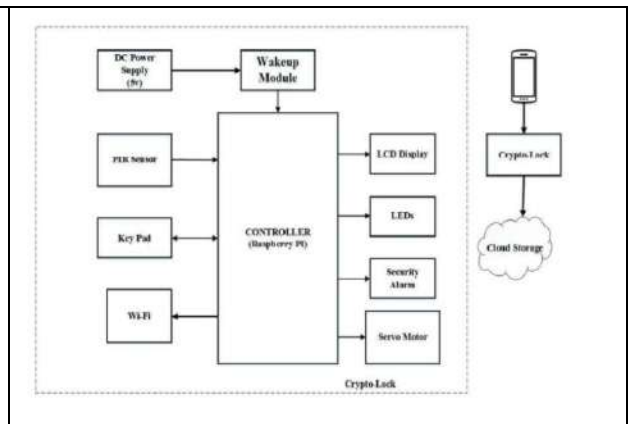
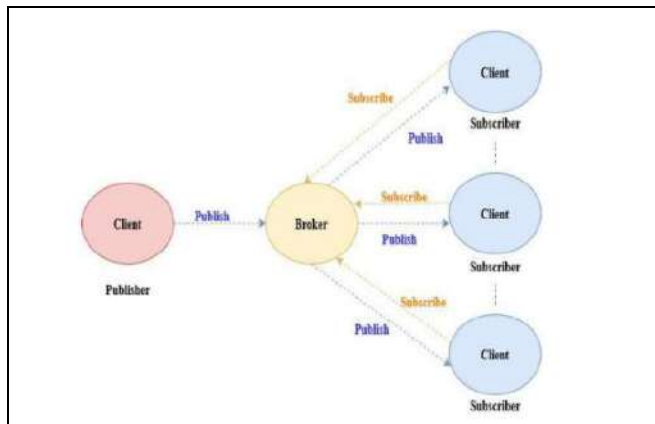
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**Table 2.1: Brute Force Attack Resistance of AES Algorithm**

Algorithm	Key (bits)	Possible Combination	Time to crack
DES-256 bit	56	$7.2 \times 10^{16}$	399 Seconds
AES-128 bit	128	$3.4 \times 10^{38}$	1.02*10 <sup>18</sup> years
AES-192 bit	192	$6.2 \times 10^{57}$	1.872*10 <sup>57</sup> years
AES-256 bit	256	$1.1 \times 10^{77}$	3.3*10 <sup>56</sup> years

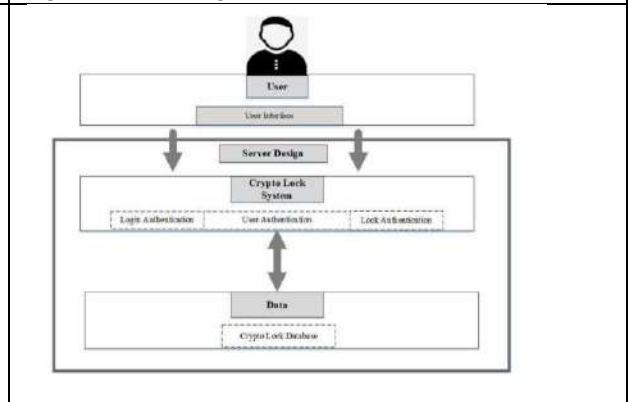
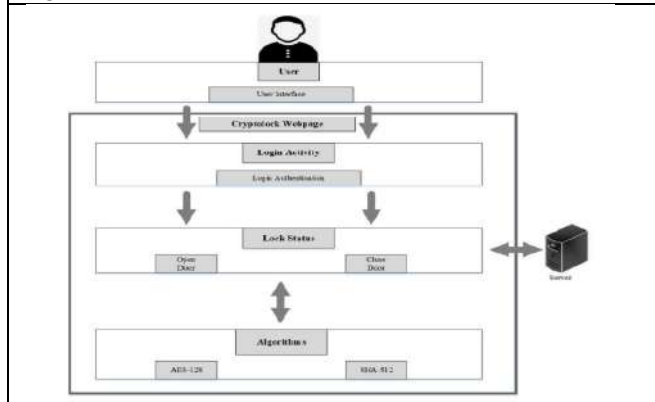
**Table 2.2: A Comparison chart of SHA Algorithms**

Algorithm	Message Length (bit)	Block Size(bit)	Word Size(bit)	Size of the Message Digest (bit)
SHA- 1	< 2 <sup>64</sup>	512	32	160
SHA- 256	< 2 <sup>64</sup>	512	32	256
SHA- 384	< 2 <sup>128</sup>	1024	64	384
SHA- 512	< 2 <sup>128</sup>	1024	32	512



**Figure 2.1: MQTT Protocol; Architecture**

**Fig: 2.2 Block Diagram**



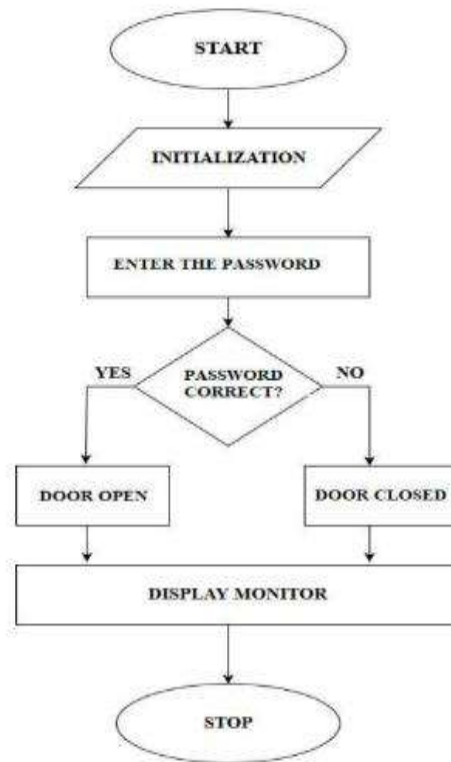
**Figure: 2.3 Webpage Architecture**

**Figure 2.4: Server Design**





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Flowchart





## Comparing Perspectives: Analysing the Gendered Division of Unpaid Care Work through the Resource-Based and Gender-Centred Approaches.

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### ABSTRACT

This paper seeks to examine and contrast two approaches that elucidate the allocation of unpaid household labour and care giving responsibilities for family members. By employing both the resource-based and gender-centric approaches, the article provides supporting evidence concerning the distribution of unpaid work among men and women. The resource-based approach posits that the relative resources of the wife determine her bargaining power within the household, which in turn enables her to bargain out of household work. Conversely, the gender-centric approach contends that the allocation of unpaid responsibilities within the household follows gendered patterns, with women and men adhering to traditional gender roles. Although the resource-based approach offers some insights into the division of unpaid care giving duties, the gender-centric approach provides a more comprehensive explanation. A compelling theory is the gender deviance neutralisation perspective, suggesting that the influence of the wife's relative resources on reducing housework is limited. When the wife earns more than the husband, she may increase her involvement in household chores to compensate for deviating from traditional gender roles. Using the two perspectives, the paper explores the nuances of the gendered distribution of unpaid work.

**Keywords:** unpaid care work, gender roles, bargaining, household chores, bargaining



**Dev Mathew and Siby Abraham**

## INTRODUCTION

Unpaid care work is primarily seen as women's work. Unpaid care work includes household maintenance, care of people in the household and voluntary community service [1]. Leaving aside voluntary community services, women contribute a major part to the other two categories- household work and care for family members. Unlike market work, women undertake unpaid care work in the household as obligations without remuneration. Just like paid work, unpaid work requires effort. Also, one could be paid to do these household chores and family care[2]. Evidence shows that the gender gap in unpaid care work exists, although there has been significant improvement recently. The time allocation to different jobs differs from person to person. In the case of women, the pattern of time allocation is quite predictable. This is because, globally, women spend much time on unpaid care work. Ferrant et al.[3] argue that although there are regional differences, on average, women spend about two to ten times that of men on unpaid work. The authors also discuss women's 'double burden', where they must find time for household chores and family care even when employed. One method by which this gender inequality within the household is addressed and measured is the time use survey. Time use surveys measure people's time allocation to different activities, usually in a day. Many countries conduct national time use surveys regularly or gather time use data along with other major surveys. Common methods of collecting time use data include stylized questionnaires, 24-hour time diaries, and interviews. Time use surveys from different countries provide insights into the regional nuances in time allocation of men and women. Evidence from national time-use statistics across the globe shows that men and women spend most of their time on personal care and maintenance, followed by social life and leisure [4].

It is interesting that while the next category to which men allocate most of their time is paid work, it is unpaid work for women. This clearly shows the disparity not only in the workplace but also in the household. In India, time use surveys were conducted twice; the pilot time use survey was conducted in 1998, and the first national Indian time use survey was conducted in 2019. The pilot survey conducted in 1998 only covered six states in India, while the one conducted in 2019 covered the entire country. While males in India, on average, spend less than three hours a day on unpaid care work in the household, females spend more than seven hours on the same. The gender difference in paid work time is quite concerning as well. While men spend more than seven and a half hours a day on paid work, women spend five and a half hours on the same. Although there is no stark rural-urban difference in the time spent on unpaid care work, there is a significant difference in the paid work time. While urban men spend more than eight and a half hours daily on paid work, rural men spend more than seven hours on the same. Urban women spend around an hour more than rural women on paid work daily. An average urban Indian spends around 1.25 hours more than the average rural Indian[5]. There are two mainstream approaches which seek to explain the allocation of time in the household: the resource-based approach and the gender-centred approach. This paper aims to compare and contrast these two approaches that explain the division of unpaid care work within the household. The article combines evidence from various sources to elucidate which approach better explains the division of unpaid care work within the household.

### The Resource-Based Approach

The relative resources and bargaining power perspective assumes that the status of a person in the household determines his/her bargaining power within the household, which in turn is associated with the household division of unpaid care work[6]. The relative resources, which include education, employment, and income, determine the household member's status within the household. Using this status, the spouse bargains out of the unpaid work in the household. Typically, men are more educated and employed and earn more than their female counterparts. Based on the relative resources and bargaining principle, we could say that men bring more resources into the household than women. These higher resources increase men's power in the household, which helps them bargain out of the tiresome unpaid work. Also, the more resources a wife brings into the household, the more is her bargaining power. Studies have shown that women with higher education, employment, and earnings do significantly less household work than women with less education, employment, and earnings [7], [8]. The problem



**Dev Mathew and Siby Abraham**

with the relative resources perspective is that it does not consider the gender aspect of household labour. The resource-based approach suggests that irrespective of gender, the spouse with relatively fewer resources (education, employment, and income) is left with no choice but to engage in more unpaid work. Therefore, the explanation of the gendered division of household work is that generally, the wife brings fewer resources into the household than the husband[7], [9]. This means the husband has more bargaining power than his wife, helping him reduce the time he spends on unpaid work. The wife has less status/power than her husband, leaving her with no choice but to take up more unpaid care work. The resource-based approach does not consider the traditional gender roles prevalent in society or the gender attitude of spouses. This is a severe drawback of the bargaining perspective.

**The Gender-Centred Approach**

The gender-centred approach argues that the household is gendered as it is not merely the relative resources which determine the division of unpaid care work but gender roles, gender attitudes, etc. The traditional gender norm views the husband as the household's breadwinner and the wife as the one who takes care of duties within the household. Any deviance from this might be seen as an 'abnormal' behaviour. In this approach, we look at two theories: the doing gender perspective and the gender deviance neutralisation theory. The doing gender perspective argues that men and women learn their roles through gendered socialisation and do what society expects them to do[10]. The authors argue that family is heavily gendered. Therefore, the division of unpaid care work in the household is due to husbands and wives performing their expected roles. It does not matter if the wife is more educated or earns more than the husband. The only thing that matters is that the spouses adhere to traditional sex-typed chores, leading to women engaging more in routine household work and men engaging more in non-routine house repairs. An interesting theory is the gender deviance neutralisation perspective or the compensatory gender display theory. It holds that women and men conform to traditional gender roles, and any deviance from traditional roles is compensated to reaffirm their gender roles[8]. When the wife out earns her husband, the couple is deviating from traditional gender roles of men being the breadwinners and women being the carers. So, to comply with the traditional norm, the wife may take up more unpaid work, and the husband may refuse to do any housework. So, according to this perspective, the bargaining perspective might work unless the husband earns more than his wife. When the wife earns more than her husband, she might engage in more household work, complying with the traditional gender roles.

**Which Approach Better Explains the Division of Unpaid Care Work?**

The resource-based approach can be elucidated from various studies. Kan and He [11] found that both men's and women's housework time is determined by their working hours and income relative to their partners. This means that the more time men and women spend in the market, the less time they spend in household work. Also, housework time is negatively associated with their share of contribution towards family income. Yokying et al.[12] iterate that spouses' contribution to household work is determined by their relative bargaining position. The authors conclude that an increase in one's partner's predicted earnings positively affects his/her contribution to household work. This is observed in the case of both men and women. In urban China, the relative resources theory could explain the division of household work[13]. The authors posit that the time the wife spends on housework consistently decreases by approximately eight hours per week as she transitions from being completely dependent on her husband to contributing two-thirds of the couple's total income. This decline continues until it reaches a minimum when she reaches the two-thirds income contribution point. Zhao[14] analysed the effect of relative resources on the division of childcare in China and found supporting evidence for the bargaining perspective. A full-time job status in rural areas helped women bargain out of childcare. Also, men bargain out of childcare as their relative income increases. This is observed only in rural areas and not in urban areas. Contrary to Zhao's [14] findings, Kan and He [11] and Yu and Xie [13] observe that the resource-based approach better explains the division of housework in urban areas than in rural areas. Although Kan and He [11] found evidence for the resource-based approach, they affirmed that in rural areas, there is evidence of 'gender display'. It could be because rural households uphold traditional gender norms. These provide evidence that gender roles and gender ideology have significant roles in determining the division of unpaid work. Quadlin and Doan [15] inspected the effect of urban city on housework and found that men in urban, suburban, and rural areas were identical in the case of female-typed



**Dev Mathew and Siby Abraham**

chores. Although urban men presumably hold egalitarian gender attitudes compared to their rural counterparts, men, regardless of their gender attitudes, do not contribute significantly to female-typed chores. Zhai et al. [16] explain the effect of education on couples' time use and find that although education helped narrow the gender gap in unpaid work in urban households, there was no housework-reducing effect in the case of rural households. On the other hand, rural women with equal levels of education compared to their husbands increased the time they spent on unpaid work. This could be a way to compensate for their deviance from traditional gender norms. Although Zhao [14] put forth evidence for the bargaining perspective in rural areas, the case of urban areas is the opposite. Urban men with higher income had more egalitarian gender attitudes compared to the lower income category and engaged more in childcare. Urban men did not bargain out of childcare as income increased. Which approach better explains the division of unpaid care work is quite tricky. Both approaches explain it to some extent. The resource-based approach might apply to the educated, urban households with higher earnings. In contrast, the gender-centred approach is more apt for the less educated rural households in the low-income category. The compensatory gender display perspective is also evident in studies on urban households. So, the relative resources theory could explain a part of the gender division of unpaid care work, and the gender approach could explain a significant part.

**CONCLUSION**

The evidence regarding which approach better explains the division of unpaid care work in the household is mixed. Studies show that both approaches provide explanations for the same. A significant drawback of the resources-based approach is that it assumes that gender roles and norms have nothing to do with household time allocation. It posits that household time allocation is explained by the relative bargaining position of the husband and wife. The gender disparity in unpaid care work is explained by the fact that women generally bring fewer resources into the household than men. Proponents of the relative resources theory hold that if women were more educated than men or earned more than men, men would have taken up more of the housework. But this is far from the truth. Evidence suggests that it is not merely the relative resources and bargaining position that determines the division of unpaid care work. It is largely explained by the gender roles prevalent in society. Traditionally, men are typed as breadwinners and women are typed as carers. Men and women behave in accordance with their expected norms. So, the fact that men spend more time in the market and women at home is not merely because of the resources they bring in or their bargaining position. It is because men and women 'do gender' or 'display gender' to affirm their masculinity and femininity. Evidence has shown that the bargaining perspective explains the division of household work in developed countries [7], [8]. This might be because men and women more or less have equal levels of education, have similar earnings and hold egalitarian gender attitudes. On the other hand, the gender-centred approach is more comprehensive in that it considers people's gender roles and attitudes. The gender-centred approach has indeed failed to explain the division of household labour in some developed countries, but it is more holistic than the resource-based approach.

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**Dev Mathew and Siby Abraham**

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## Enhanced Traceable CP -ABE for Effective Data Transmission in Military Systems

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### ABSTRACT

When communications are to be shared amongst users via an untrusted media, security must be guaranteed. Within the military setting, users of varying grades must communicate sensitive information to one another. To safeguard the data from unwanted access, the information that must be delivered must be encrypted. Identity-based encryption, attribute-based encryption (ABE), key policy attribute-based encryption (KP-ABE), and cipher text policy attribute-based encryption (CP-ABE) are some of the techniques available for encrypting data. In CP-ABE, attributes are linked to the key and access policies are linked to the cipher text. Decryption is only feasible if the attribute and the access policy match. Traceability, blocking characteristics, and a vast universe are added to cp-abe.

**Keywords:** CP-ABE (Cipher text policy attribute encryption), IBE (Identity – Based Encryption), FIBE (Fuzzy identity based encryption), PKG (Public Key Generator)

## INTRODUCTION

Computer Security is a technique used to ensure that the data stored in the computer isn't compromised. There are colorful styles to ensure security like word, data encryption etc. Data encryption means cracking the data into another form which can be deciphered only by decryption key. The military communication had the topmost





Anusha Sivanandhan et al.,

influence on encryption. A thorough understanding encryption helps people to develop better ways to cover precious information because the technology has come briskly and more effective. The cipher textbook and secret key in trait-based encryption are dependent on the traits. The identity of the user is described by a set of trait. Cipher text- policy trait- grounded encryption (CP- ABE) enables fine- granulated access control to the translated data for marketable operations. Due to two components, huge macrocosm and traceability, CP-ABE has advanced significantly in recent years, substantially improving its marketable operations. The capacity of ABE to track down the malicious user who purposefully makes a mistake with the partial or altered decryption keys in order to profit is known as traceability. However, because of the nature of CP-ABE, it is challenging to determine the original key owner from an exposed key because the decryption privilege is shared by several users with identical characteristics.

## Related Works

### Identity Based Encryption

A user's public key in an IBE system could be any string, such as their email address or another identification. This completely removes the need for certificates because the sender can just encrypt the message using the recipient's identity without first obtaining his public key (and making sure that the public key obtained is the correct one). Naturally, people are unable to create a private key for an identity on their own[1]. Because of this, the system setup is carried out by a reliable party known as the private key generator (PKG). A user would visit the PKG and provide identification in order to receive a private key for his identity. The relevant private key would then be generated by the PKG and sent on.

### Fuzzy Identity-Based Encryption

An identity is seen as a collection of descriptive features in Fuzzy IBE. When two identities,  $I_1$  and  $I_2$ , are close to one another as determined by the "set overlap" distance metric, a fuzzy IBE method permits a private key for identity  $I_1$  to decrypt a cipher text encrypted with identity  $I_2$ . Biometric identities can be encrypted using a fuzzy IBE scheme because of its error-tolerance feature, which makes it possible to use biometric identities despite the fact that they will always contain some noise when they are sampled. Furthermore, we demonstrate the applicability of Fuzzy-IBE for what we refer to as "attribute-based encryption" applications.

### Key-policy attribute based encryption

Characteristics are appended to the cipher texts, and users' decryption keys are distributed in line with an access policy in the KPABE. The attribution set can be encrypted by ABE, and KP-ABE ensures that the identical attribution sets will correlate. Nevertheless, ABE is unable to recognize the users who may have access to the encrypted data files. The primary characteristics of users in KP-ABE are linked to an ACT that consists of those same characteristics[6]. Relying on an external key authority prevents users from accessing and reading the data files. One crucial characteristic that must be attained in kp-abe is collusion resistance. This essentially means that separate users shouldn't be able to combine their secret keys to decrypt a cipher text that neither of them could decode alone.

### Enhanced Traceable Large Universe CP-ABE System

We use the "individual randomness" and "layer" techniques from [9] and [13] to realize huge universe creation. To safely encrypt and decrypt data, we employ the "layer" technique. The "attribute" layer and the "secret sharing" layer are the two "layers" we use. A "binder term" is used to securely join these two layers. We use  $u, h$  words in the "attribute" layer to produce a hash function ( $uAh$ ) in the Boneh-Boyen manner [14]. Regarding the "secret sharing" layer, we utilize the  $w$  term to store the secret randomness shares  $s$  ( $r$ ) and the secret randomness ( $w$ ) throughout the KeyGen and Encrypt phases, respectively. Lastly, we "bind" these two layers together using the  $v$  word. We employ the Boneh-Boyen-style signature [14] in the T-LU-CPABE system and other systems to achieve traceability. An eT-LU-CP-ABE system consists of six algorithms as follows

1. **Setup** A security parameter  $\lambda \in \mathbb{N}$  encoded in unary is fed into the method as an input. It outputs the master secret key (msk) and the public parameters (pp). We presume that the public parameters provide the description of the attribute universe  $U$ . Furthermore, it initializes an instance of INS ( $(t, n)$ ), which is Shamir's ( $(t, n)$ ) threshold scheme.





Anusha Sivanandhan et al.,

2. **Key Gen** The public parameters  $pp$ , the master secret key  $msk$ , and a set of attributes  $S \subseteq U$  for a user with identification  $id$  are inputs to the key generation process. The inputs' security parameter guarantees that the time is polynomial in  $\lambda$ . The secret key  $skid, S$ , corresponding to  $S$ , is the algorithm's output.
3. **Encrypt** An access structure  $A$  over  $U$ , a plaintext message  $m$ , and the public parameters  $pp$  are the inputs of the encryption method. The cipher text  $ct$  is output by it.
4. **Decrypt** The public parameters  $pp$ , a secret key  $skid, S$ , and a cipher text  $ct$  are inputs to the decryption method. The plaintext  $m$  or  $\perp$  is output by it.
5. **Key Sanity Check** A secret key  $sk$  and the open parameters  $pp$  are inputs to the decryption handle.  $Sk$  yields 1 on the off chance that the key rational soundness check is effective. In the event that not, it produces 0. A deterministic method called the key rational soundness check is utilized to guarantee that 17 the secret key is well-formed amid the decoding handle.
6. **Trace** The fraudulent user is located using this algorithm. The aforementioned technique allows us to determine whether the key was well formed or not.

### Proposed System

In military different users that belong to different ranks needs to communicate with each other to transfer the confidential data. Table I shows some of the ranks of the officers in the army. When a new user wants to enter the system the corresponding request is send to his immediately top priority user as shown in Fig. 1. The top priority user can either activate or deactivate the request. If the top priority user activates the request then the requested user can enter the system. If the top priority user deactivates the request then the user cannot enter the system. First the document has to be uploaded by the sender to send the document to the receiver. After file uploading, the document will be encrypted and send to the receiver. The secret key and pin code will be generated when the encrypted data is sent to the receiver. This secret key and pin code will be sent to the receiver through email. If the receiver gives valid secret key and pin code, then they can decrypt the document. If the pin code is invalid that user will be temporarily blocked and cannot enter the system. The blocked user can send the unblocking request to the admin. The admin can unblock the user if wanted. After unblocking if the user again gives invalid pin code then that user will be blocked for permanently as shown in Fig. 2.

### CONCLUSIONS

In the military, it is necessary for users of different ranks to transmit classified information. In order to achieve this, an enhanced large universe cipher text policy attribute-based encryption is suggested. This feature includes the ability to trace malicious users who attempt to provide invalid keys, as well as the ability to block such users from further attacks. The large universe attribute-based encryption does not require fixing during system setup. Systems known as CPABE have been created that incorporate white box traceability of permitted harmful users. We can identify the dishonest users who, in order to make money, give out partial or altered decryption keys to third parties. The public parameters size does not increase linearly with the amount of attributes, and the attribute size is unlimited. In addition, we optimize the system in tracing the malicious users to cut down the storage cost for traceability and to make the system efficient in the revocation of the users. Based on the above advantages, our new systems could be applied to many scenarios such as pay-tv systems and social networks. This system is selectively secure in the standard model, when compared with others.

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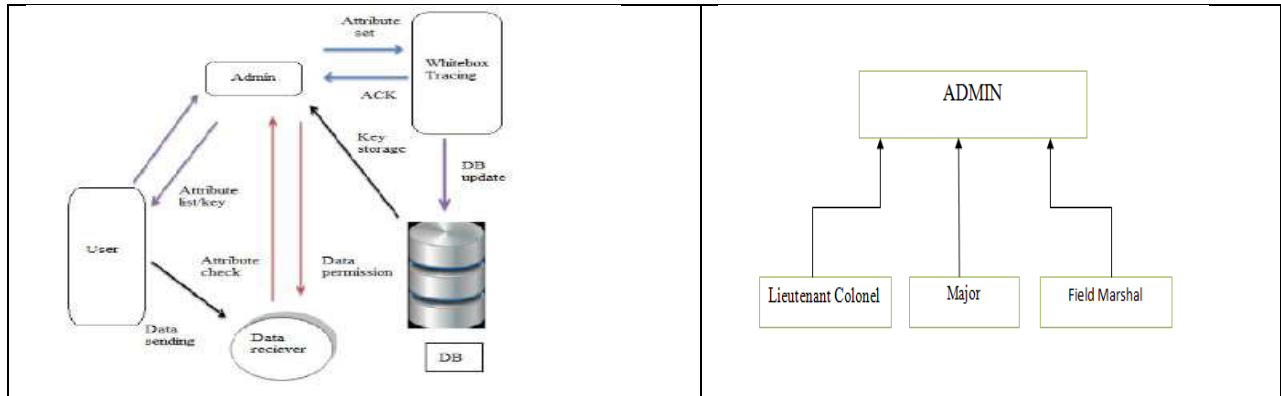
**Table I Ranks in army**

PRIORITY	RANK
Major	1
Lieutenant Colonel	2
Brigadier	3
Major General	4
Lieutenant General	5
General	6





Anusha Sivanandhan et al.,



Enhanced Traceable Large Universe CP-ABE System

Fig. 1 Request to enter the system

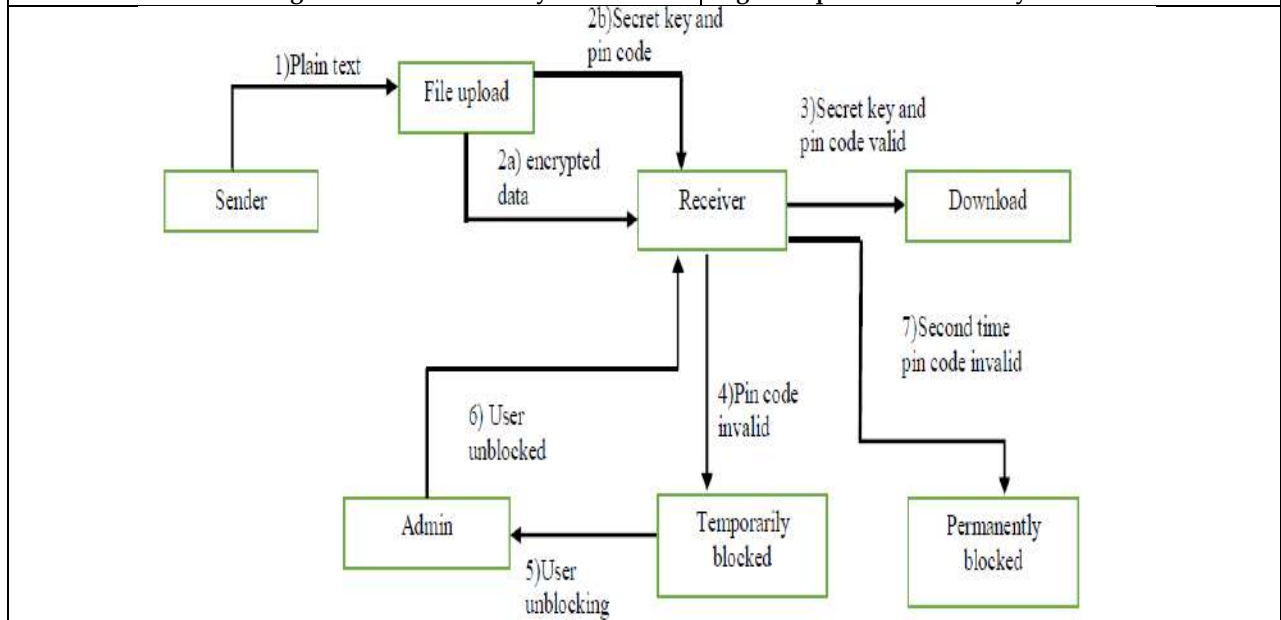


Fig. 2 Block diagram of proposed system







# The Impact of Environmental Education on Shaping Eco-conscious Citizen

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## ABSTRACT

Environmental education plays a pivotal role in shaping the mindset and behaviors of individuals towards ecological sustainability. This study delves into the transformative impact of environmental education initiatives on fostering eco-consciousness among diverse populations. The primary objectives were to assess attitude shifts, measure community engagement, and investigate the influence across demographic groups following exposure to structured environmental education programs. Drawing upon a mixed-methods approach, this research surveyed participants before and after their involvement in environmental education initiatives, capturing shifts in attitudes towards environmental issues. Quantitative data revealed a notable increase in positive attitudes, coupled with a corresponding willingness to engage in sustainable behaviors post-education. Additionally, qualitative insights unveiled nuanced shifts in perceptions and behavioral intentions, highlighting the depth of impact. The study further documented a measurable rise in community engagement within the realms of environmental activism and local initiatives. Participants exhibited heightened involvement in community-based environmental projects post-education, demonstrating a tangible connection between education and increased civic participation. Moreover, the investigation into diverse demographic groups illuminated varying responses to environmental education interventions. Differential impacts were observed across age groups, socioeconomic strata, and cultural backgrounds, shedding light on the need for tailored approaches to effectively influence eco-consciousness. This study underscores the significance of environmental education as a catalyst for fostering a more environmentally aware and active citizenry. The findings offer empirical evidence of the transformative power of structured environmental education, paving the way for targeted strategies aimed at shaping eco-conscious citizens and driving collective action towards environmental sustainability.

**Keywords:** Environmental Education, Eco-consciousness, Attitude Shifts, Community Engagement



**Vandana and Githin T James**

## INTRODUCTION

In an era defined by pressing environmental challenges, the imperative for cultivating eco-consciousness and fostering proactive environmental stewardship has become increasingly urgent. At the heart of this imperative lies the role of environmental education as a powerful catalyst in shaping individuals into informed, engaged, and environmentally responsible citizens. This paper seeks to explore and elucidate the profound impact of environmental education programs on individuals, communities, and society at large. Environmental education stands as a pivotal tool in empowering individuals with the knowledge, skills, and attitudes necessary to comprehend, engage with, and address complex environmental issues. As the world grapples with climate change, biodiversity loss, resource depletion, and other ecological crises, the need to nurture a generation of environmentally literate and empathetic citizens has garnered unparalleled significance. This research aims to delve into the transformative potential of environmental education across various contexts, ranging from formal classroom settings to community-based initiatives and experiential learning platforms. It seeks to unpack the multifaceted outcomes of such educational interventions, examining their influence on individuals' perceptions, behaviours, decision-making processes, and active involvement in environmental conservation efforts.

The paper will traverse through empirical studies, case analyses, and theoretical frameworks, shedding light on the mechanisms through which environmental education shapes individuals into eco-conscious citizens. It will underscore the importance of not merely disseminating information but fostering critical thinking, empathy towards nature, and a sense of responsibility towards environmental sustainability. Moreover, the research will explore the long-term implications of effective environmental education, investigating how it influences individuals' lifestyles, consumption patterns, and contributions to collective efforts aimed at preserving and rehabilitating our planet's fragile ecosystems. By examining the nuanced and profound impact of environmental education on shaping individuals' mind-sets and behaviours, this paper endeavours to underscore its role as a linchpin in building a society of environmentally aware, engaged, and empowered citizens committed to the well-being of our planet. This introduction sets the stage for the exploration of environmental education's impact on shaping eco-conscious citizens. It outlines the rationale behind the research and highlights the key areas that the paper aims to explore further.

### Objectives

1. To assess the shift in attitudes towards environmental issues before and after exposure to environmental education initiatives.
2. To Measure the extent to which environmental education contributes to increased engagement in community-based environmental initiatives or activism.
3. To Investigate how environmental education influences diverse demographic groups

## RESEARCH METHODOLOGY

A systematic review was done to understand the Impact of Environmental Education on Shaping Eco-conscious Citizens such a process helps to answer the research questions of the study. Keyword such as Eco-consciousness, Citizen Engagement. were employed to explore the various literatures related to the study. Descriptive research design is also adopted for the study.

### Relevance Of Environmental Education On Shaping Eco-Conscious Citizens

The relevance of environmental education in shaping eco-conscious citizens is profound and multifaceted, influencing individuals, communities, and society at large in several critical ways:



**Vandana and Githin T James****Knowledge Acquisition**

Environmental education serves as a vehicle for imparting knowledge about ecological systems, biodiversity, climate change, and sustainability. It equips individuals with a deeper understanding of environmental issues, fostering awareness about the interconnectedness between human activities and the natural world.

**Attitude and Behaviour Change**

It plays a pivotal role in transforming attitudes and behaviours toward the environment. By instilling empathy, fostering a sense of responsibility, and promoting critical thinking, environmental education encourages individuals to adopt more sustainable lifestyles, reduce their ecological footprint, and make informed choices.

**Empowerment and Engagement**

Environmental education empowers individuals to become proactive agents of change. It encourages citizen engagement by providing tools, resources, and a platform for active participation in environmental conservation efforts. This engagement can manifest through community initiatives, advocacy, policy-making, and sustainable practices in daily life.

**Long-term Impact**

The impact of environmental education extends beyond immediate awareness. It influences long-term decision-making processes, shaping future generations into environmentally conscious citizens who prioritize sustainability in their personal and professional endeavours. This long-term perspective is crucial for addressing persistent environmental challenges.

**Creating Responsible Stewards**

It cultivates a sense of environmental stewardship, encouraging individuals to take responsibility for the well-being of the planet. This stewardship mind-set fosters a sense of connection to nature and a commitment to preserving ecosystems for current and future generations.

**Contributing to Global Solutions**

In a global context where environmental issues transcend borders, environmental education cultivates a global perspective. It encourages collaboration, understanding, and collective action among diverse communities and nations to address shared environmental challenges.

**Supporting Policy and Advocacy**

Eco-conscious citizens, informed by environmental education, often become advocates for policy changes and sustainable practices. They play a pivotal role in shaping public opinion and supporting policies that prioritize environmental conservation and sustainability. In essence, the relevance of environmental education lies in its capacity to shape individuals into informed, empathetic, and proactive stewards of the environment. It bridges knowledge with action, fostering a sense of responsibility and empowerment crucial for addressing the complex environmental issues facing our world today.

**Initiatives Aimed At Environmental Education And Shaping Eco-Conscious Citizens**

India has several programs and initiatives aimed at environmental education and shaping eco-conscious citizens. Here are some prominent ones

**National Green Corps (NGC)**

Also known as "Eco-Clubs," NGC is an initiative by the Ministry of Environment, Forest, and Climate Change (MoEF). It aims to involve school students in environmental conservation through various activities, workshops, and projects.

**Environmental Studies (EVS) in Education Curriculum**

The Indian education system includes Environmental Studies as a compulsory subject in schools to raise awareness about environmental issues and sustainability from an early age.

**Centre for Environment Education (CEE)**

CEE is a leading organization working towards environmental education and conservation. It conducts various programs, workshops, and initiatives across the country to promote environmental awareness and action.

**Green Schools Programme by Centre for Science and Environment (CSE)**

This program engages schools to adopt sustainable practices, reduce their environmental impact, and integrate environmental education into their curriculum.



**Vandana C H and Githin T James****TERI School of Advanced Studies**

The Energy and Resources Institute (TERI) offers educational programs focusing on sustainable development, environmental studies, and sustainable management practices.

**Project WET (Water Education for Teachers)**

It's an international program that's been implemented in India to educate teachers about water-related issues and foster water conservation practices among students.

**WWF-India's Education for Sustainable Development (ESD) Program**

WWF-India conducts various education initiatives aimed at fostering sustainability, biodiversity conservation, and climate action among students and communities.

**State-Level Initiatives**

Many Indian states have their own environmental education programs and initiatives integrated into school curricula, often in collaboration with governmental and non-governmental organizations. These programs vary in scale and focus, but collectively they aim to integrate environmental education into formal schooling, engage communities, and promote sustainable practices. They often involve a combination of curriculum development, teacher training, awareness campaigns, and on-ground projects to shape eco-conscious citizens across different age groups and regions in India.

**Findings**

A significant increase in positive attitudes towards environmental issues post-environmental education programs, evidenced by survey responses or attitude scales. Demonstrable evidence of increased participation in community-based environmental projects among individuals who have undergone environmental education. Identification of specific areas or types of community initiatives that witness heightened involvement due to environmental education, like local clean-up campaigns, tree planting drives, or advocacy for sustainable practices. Quantifiable data showcasing the rise in volunteerism or active involvement in environmental groups post-education. Demonstrable evidence of increased participation in community-based environmental projects among individuals who have undergone environmental education. Identification of specific areas or types of community initiatives that witness heightened involvement due to environmental education, like local clean-up campaigns, tree planting drives, or advocacy for sustainable practices. Quantifiable data showcasing the rise in volunteerism or active involvement in environmental groups post-education.

**Suggestions**

The world stands at a critical juncture, where the future of our planet hinges on the actions we take today. Amidst the complexities of climate change, biodiversity loss, and resource depletion, one beacon of hope illuminates our path: environmental education. As we envision the future, it becomes increasingly evident that the evolution of environmental education will shape the very fabric of our societies and our relationship with the natural world. The future of environmental education is not merely confined within classroom walls; it extends far beyond, transcending borders and cultural divides. It is a dynamic force that blends innovation, collaboration, and a profound understanding of our interconnectedness with the environment. Technology, that ever-evolving tapestry of human innovation, will weave itself intricately into the narrative of environmental education. Virtual reality, online platforms, and interactive tools will bring the wonders of nature and the urgency of conservation efforts directly into our homes and classrooms. These technological advancements will not only enhance accessibility but also kindle a passion for environmental stewardship among digital natives, fostering a generation of eco-literate individuals poised to tackle global challenges. Yet, the heart of environmental education lies in its ability to inspire action and instil a sense of responsibility. Tomorrow's curriculum will emphasize experiential learning, empowering learners to immerse themselves in nature, to witness its beauty, understand its fragility, and act as custodians of its future. Project-based initiatives, community engagement, and youth leadership programs will sow the seeds of change, nurturing a collective consciousness that transcends boundaries and ideologies. Our educational landscape will



**Vandana and Githin T James**

witness a transformation, embracing an interdisciplinary approach that marries environmental sciences with social sciences, arts, and humanities. This fusion will breed a holistic understanding of environmental issues, recognizing the intricate interplay between ecological balance and societal well-being. Moreover, the future of environmental education is a call for inclusivity and diversity. It recognizes and respects indigenous knowledge systems, amplifies diverse voices, and cultivates an understanding that environmental challenges demand solutions rooted in cultural sensitivity, equity, and social justice. As we stand on the cusp of this transformative journey, the future of environmental education is a clarion call for action. It beckons educators, policymakers, communities, and individuals alike to join hands in nurturing a generation of eco-conscious citizens, equipped with the knowledge, skills, and empathy needed to safeguard our planet.

**CONCLUSION**

In conclusion, the profound impact of environmental education in shaping eco-conscious citizens is undeniable. Through its multifaceted approaches, this form of education transcends traditional boundaries, fostering a generation poised to tackle the complex environmental challenges that lie ahead. Environmental education serves as a catalyst, empowering individuals with knowledge, skills, and a deep-rooted connection to the natural world. It not only instills an understanding of ecological systems but also cultivates empathy, responsibility, and a sense of stewardship towards our planet. The journey of environmental education towards shaping eco-conscious citizens encompasses various dimensions. It embraces innovative pedagogies that merge technology with experiential learning, offering immersive experiences that kindle a passion for environmental stewardship. Moreover, it emphasizes the importance of inclusivity, diversity, and the integration of indigenous wisdom, recognizing the richness of different perspectives in tackling global environmental issues.

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# Enhancing Digital Infrastructure for Sustainable Development: Addressing Challenges and Solutions in Ensuring Data Security in the Internet of Things

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## ABSTRACT

With its ability to connect a wide range of objects and facilitate smooth communication and data sharing, the Internet of Things (IoT) has become a paradigm-shifting technology. This study examines the complex issues surrounding data security in the Internet of Things ecosystem and suggests creative solutions to these problems. The main issues noted are the diverse character of IoT devices, the computing limitations, and the requirement for effective encryption techniques to safeguard sensitive data. This study highlights the significance of a comprehensive approach to data security and examines the effects of these issues on the overall security posture of IoT systems. In order to address these issues, the study offers a thorough architecture that combines sophisticated encryption methods, reliable authentication systems, and customized security protocols made especially for the Internet of Things.

**Keywords:** Internet of Things (IoT), Data security, Heterogeneous IoT devices, Encryption methods, Computational capabilities.

## INTRODUCTION

With the emergence of the Internet of Things (IoT), common things are now part of a networked ecosystem that is capable of collecting and exchanging data thanks to sensors, actuators, and connectivity. Because of this interconnectedness, smart ecosystems may be built, facilitating improved automation, control, and monitoring for a wide range of applications. With the promise of previously unheard-of levels of productivity, efficiency, and creativity, the Internet of Things has quickly become prominent in a number of industries, including manufacturing,





**Dhanya G .S**

transportation, healthcare, agriculture, and smart cities. The Internet of Things (IoT) presents a plethora of opportunities and challenges as it grows. IoT device integration creates new opportunities for data-driven decision-making and better user experiences, but it also brings up issues with security, privacy, and the efficient handling of the massive volumes of data produced. Developing strong security protocols to safeguard the confidentiality and integrity of data transferred over these networks is one of the major obstacles to the broad use of IoT technologies. The goal of this study is to investigate the complex terrain of the Internet of Things, with a particular emphasis on the difficulties in guaranteeing data security in this networked setting. We aim to reveal the complexity resulting from the heterogeneous nature of IoT devices, the limitations imposed by their processing capabilities, and the need for effective encryption techniques to protect sensitive data through a thorough examination of the literature that has already been published.

The research draws upon a foundation of established studies to examine the implications of these challenges on the overall security posture of IoT systems. Notably, the work of authors [1] provides insights into the key architectural components of IoT, while the security aspects are enriched by the contributions of authors [2][3]. In response to the identified challenges, this research proposes a comprehensive framework designed to address the unique security considerations of IoT devices. By integrating advanced encryption techniques, robust authentication mechanisms, and tailored security protocols, the framework aims to strike a delicate balance between ensuring data security and accommodating the resource limitations inherent in IoT devices. As we navigate through the subsequent sections of this research article, we will delve into the theoretical foundations, practical implications, and potential future directions for securing IoT in the context of data exchange. By synthesizing insights from diverse sources, this research contributes to the ongoing discourse on IoT security, offering practical solutions and recommendations to fortify the integrity of the IoT ecosystem.

**Challenges**

The Internet of Things (IoT) poses a complex environment with a number of issues related to data security that require careful thought. Here, with the help of pertinent sources, we examine some of the major IoT data security challenges.

**Heterogeneous Device Ecosystem****Challenge**

The diverse range of IoT devices, each with its own specifications and capabilities, poses challenges in implementing standardized security measures [4]. The first section of the paper discusses the current state of IoT security, highlighting how crucial it is to secure the networked devices that make up the IoT. It draws attention to the dangers and weaknesses present in the varied and growing IoT environment. The writers talk about how strong security protocols are necessary to protect private information and guarantee the dependability of Internet of Things applications. The report then goes on to describe the difficulties in protecting IoT devices. The heterogeneity of IoT devices, each with distinct specs and capabilities, is one major difficulty that has been emphasized. Standardized security measure creation is made more difficult by this variability. The authors also discuss the limitations that the computing capabilities of IoT devices have, highlighting the difficulties in putting in place efficient security measures. Presenting potential future approaches for IoT security, the report ends. It offers ideas for possible tactics and methods to get around the problems found, giving us a better understanding of how security controls might change over time to adapt to the changing needs of the Internet of Things. The suggested future paths are intended to improve the Internet of Things' overall security posture, guaranteeing the safe and dependable growth and adoption of IoT technology. In conclusion, the study provides a thorough evaluation of the state of IoT security today, stressing difficulties brought on by resource constraints and device heterogeneity. It advances the field by outlining potential avenues for resolving these issues in the future, opening the door for an Internet of Things that is more reliable and secure.



**Dhanya G .S****Limited Computational Resources****Challenge**

Many IoT devices operate with limited processing power and memory, making it challenging to implement robust security protocols[5].The importance of IoT designs in enabling the integration and operation of various IoT components is emphasized early in the study. It examines the wide range of IoT architectures and groups them according to their functionality and design philosophies. The author emphasizes that in order to handle the increasing complexity of IoT ecosystems, scalable, interoperable, and efficient designs are required. Numerous IoT design types, such as centralized, decentralized, and hybrid systems, are included in the survey. The structure, communication methods, and applicability for various IoT applications of each kind are examined. The paper explores the essential aspects of Internet of Things designs, including data processing units, actuators, sensors, and communication protocols, explaining how each part affects the system as a whole. The essay also covers the difficulties in putting IoT systems into practice, including security, privacy, and the requirement for standardized protocols. It also looks at how cloud computing helps IoT systems work better and be more scalable. The research offers important insights into these architectures' advantages, disadvantages, and possible uses by classifying and analyzing them. The survey's conclusions advance knowledge of IoT architectural design and provide a foundation for further advancements in this rapidly evolving subject.

**Inadequate Encryption Methods****Challenge**

Ensuring secure communication in IoT is hindered by the limitations of existing encryption methods, especially when applied to resource-constrained devices[6].The poll starts off by recognizing how quickly IoT devices are proliferating and how this has led to an increase in security concerns. The writers stress how crucial it is to deal with security concerns in order to guarantee the confidentiality and integrity of data within the Internet of Things environment. The study conducts a thorough analysis of the body of research on Internet of Things security, including a range of topics including secure communication protocols, encryption, access control, and authentication. It lists and analyzes the main security issues that IoT systems must deal with, such as device heterogeneity, resource limitations, and communication channel vulnerability. The writers examine the various security measures put forth in the literature to deal with these issues. This covers a discussion of authentication strategies, encryption approaches, and secure communication protocols that are specific to Internet of Things devices. The survey also looks at how anomaly detection technologies and intrusion detection systems can improve the overall security posture of Internet of Things environments. The report concludes with a thorough analysis of IoT security, highlighting the issues and suggestions for resolution found in the body of current research. It provides insightful information about the current status of IoT security, assisting practitioners, researchers, and policymakers in comprehending the situation and making defensible choices to improve IoT system security. The poll adds to the current conversation about IoT security by compiling and combining pertinent data.

**Authentication and Authorization Issues****Challenge**

Establishing and managing secure authentication and authorization mechanisms for a multitude of devices is a complex task [7].The relevance of authentication in the Internet of Things is discussed at the outset of the article, given the rise in connected devices and the sensitive nature of the data being used. The authors examine current authentication methods that have been used in the series' IoT contexts, stressing both their advantages and disadvantages. The study looks at a number of authentication techniques, including machine authentication, biometrics, and passwords. It evaluates these methods' applicability for Internet of Things devices by taking into account things like hardware constraints, scalability, and strict security requirements. The study also looks at new developments in IoT authentication, such as the application of machine learning and block chain technology to increase security. The writers talk about how these innovations can improve overall security and solve the problems with conventional authentication techniques.



**Dhanya G .S****Lack of Standardized Security Protocols  
Challenge**

The absence of universally accepted security standards for IoT devices hampers interoperability and creates potential vulnerabilities[8].The importance of intrusion detection in Internet of Things systems is acknowledged at the outset of the study as these systems become more interconnected across multiple domains. The authors draw attention to the distinctive features of IoT, such as resource limitations, a variety of communication protocols, and the dynamic nature of IoT environments, which make it difficult to employ typical intrusion detection techniques. The survey divides the many groups of intrusion detection techniques that are currently in use—such as anomaly-based, signature-based, and hybrid approaches—and examines them. The authors analyze the benefits and drawbacks of each approach, taking into account things like scalability, adaptability to the IoT environment, and detection accuracy. The study also examines how IoT-specific issues, like the enormous number of devices, the variety of communication patterns, and the requirement for real-time analysis, affect intrusion detection. Additionally, the authors mentioned about how data mining and machine learning may improve the efficacy of IoT intrusion detection systems. The paper concludes with a thorough analysis of intrusion detection within the framework of the Internet of Things. The authors provide important insights into the prospects and difficulties of protecting IoT systems from malicious activity by reviewing the body of previous work. Researchers, practitioners, and legislators who are creating and executing intrusion detection systems customized for the particularities of the Internet of Things environment might use the survey as a reference.

**Privacy Concerns  
Challenge**

The constant generation and exchange of data in IoT raise privacy concerns, especially when dealing with sensitive information[9].The first section of the article acknowledges the Internet of Things' explosive growth and the growing demand for safe and dependable systems to manage the enormous volumes of data produced by networked devices. In order to address trust and security concerns in IoT ecosystems, the authors present block chain technology as a potential solution, highlighting its decentralized and tamper-resistant nature. The overview covers the salient characteristics of block chain, such as its distributed ledger, cryptographic concepts, and consensus processes. It investigates how these qualities might be used to improve data security, device authentication, and other areas of the Internet of Things. The writers go over certain use cases and block chain applications in the context of the Internet of Things, such as safe data sharing, smart grids, supply chain management, and healthcare. They examine how block chain technology can lessen typical difficulties in data tampering, attack and transparency failure.

**Scalability Challenges  
Challenge**

As the number of connected devices increases, managing the scalability of security solutions becomes a significant challenge[10].he authors stress how important it is to have strong security measures in place to safeguard the various connected devices that make up the Internet of Things ecosystem. The survey classifies existing security protocols for the Internet of Things (IoT) according to their major purposes, including authentication, access control, confidentiality, and integrity. It does this by methodically reviewing a wide range of these protocols. The feasibility of these protocols for various Internet of Things applications is analyzed by the authors, taking into account various issues like heterogeneity of devices, scalability, and resource restrictions. The limitations and difficulties with the security protocols in place for the Internet of Things are also highlighted in the report. Among these difficulties are the requirements for effective key management, lightweight cryptographic methods, and data protection both in transit and at rest. The writers talk about how the special qualities of IoT devices make these problems worse. The study also describes open research questions related to IoT security, offering insights into areas that need additional investigation. Creating standardized security frameworks, privacy-preserving techniques, and scalable solutions that may change with IoT deployments are a few of these. The study concludes with a thorough summary of Internet of Things security protocols. To improve the security of Internet of Things systems, academics, practitioners, and policymakers can benefit greatly from the authors' unique resource, which summarizes current solutions, evaluates



**Dhanya G .S**

their applicability, and identifies research gaps. By providing future objectives for research and development, the study consolidates existing knowledge and adds to the ongoing conversation around IoT security.

**Solutions****Encryption Techniques****Solution**

Implement strong encryption algorithms for data in transit and at rest [11]. The Internet of Things (IoT) is thoroughly covered in this paper, including its core technologies, communication protocols, and variety of applications. In addition to analyzing enabling technologies and communication protocols, it examines the importance of the Internet of Things in connecting devices, sensors, and actuators. It also provides insights into applications in the fields of industrial automation, smart cities, healthcare, and agriculture. For scholars, practitioners, and policymakers in the area, this survey is a useful tool for comprehending the various facets of the Internet of Things.

**Authentication Mechanisms****Solution**

Employ robust authentication methods for devices and users [12]. The importance of authentication in the context of the Internet of Things (IoT) is highlighted. The authors start out by stressing how important authentication is becoming because of how common IoT devices are becoming and how critical the data they manage is. The report offers a thorough examination of the current IoT authentication protocols, including device-based, biometric, and password-based techniques. It assesses these approaches' suitability taking into account the resource limitations and scalability needs of Internet of Things devices. The study examines new developments in IoT authentication, such as the fusion of machine learning and block chain technologies. The writers go over how these innovations can provide safe and effective identity verification in dynamic Internet of Things contexts by addressing the problems with conventional authentication techniques. Additionally, the article provides insights into the potential developments, standards, and research directions related to authentication in the Internet of Things. In order to handle the dynamic nature of IoT ecosystems, it highlights the necessity of adaptive and context-aware authentication procedures. All things considered, the survey offers a thorough analysis of the current situation and potential future directions of authentication in the Internet of Things, offering insightful information to scholars, industry professionals, and decision-makers.

**Secure Communication Protocols****Solution**

Use secure protocols like TLS/DTLS to protect communication [13]. Granjal, Monteiro, and Silva provide a thorough analysis of the crucial topic of security in the Internet of Things (IoT) in their study. The writers commence by recognizing the swift expansion of Internet of Things devices and the consequent rise in security apprehensions. The survey carefully classifies and assesses the security protocols now in use in the Internet of Things, with an emphasis on integrity, confidentiality, authentication, and access control. The writers analyze the benefits and drawbacks of each protocol while taking into account IoT device-specific aspects like resource limitations and scalability. The study also lists problems with the security mechanisms in place, such as the requirement for efficient key management, lightweight cryptographic algorithms, and data protection both in transit and at rest. The survey explores areas of open research and identifies areas that require more investigation, including standardized security frameworks and scalable solutions that can be adjusted to the ever-changing nature of Internet of Things deployments. The paper concludes with a thorough analysis of security protocols in the context of the Internet of Things, providing insightful information on problems, solutions, and possible directions for further study and advancement. For researchers, practitioners, and policymakers interested in improving the security of IoT systems, it provides a fundamental resource.



**Dhanya G .S****Block chain Technology****Solution**

Use block chain technology to provide safe and open transactions [14]. The review examines how block chain technology can be used to address security and reliability issues in Internet of Things ecosystems. The writers go over the main characteristics of block chain, such as decentralization and tamper resistance, and how these improve data openness and integrity in the Internet of Things. The study also looks at practical applications, such as healthcare and supply chain management, to show how block chain might lessen security risks. The review also identifies possible future advancements and obstacles in utilizing block chain for IoT, making it an invaluable tool for scholars, practitioners, and legislators who wish to comprehend how these two revolutionary technologies complement one another.

**Intrusion Detection and Prevention Systems (IDPS)****Solution**

Implement IDPS to monitor and detect abnormal activities[15].It tackles the difficulties brought about by the special features of the Internet of Things, such as limited resources and a variety of communication patterns. The efficacy of anomaly-based and signature-based intrusion detection techniques in detecting and averting security risks is assessed by the writers. The contribution of data mining and machine learning approaches to improving intrusion detection systems for the Internet of Things is also covered in this paper. In general, the study offers significant perspectives on the present condition of intrusion detection in the Internet of Things domain, rendering it an invaluable tool for scholars, professionals, and decision-makers who aim to improve the safety of IoT systems.

**CONCLUSION**

In conclusion, protecting data in the Internet of Things (IoT) requires coming up with creative solutions for a variety of complex problems. The study pinpointed several significant obstacles, such as the diverse range of devices, restricted computational power, and the requirement for effective encryption. The suggested remedies consist of an all-encompassing structure that incorporates sophisticated encryption, strong authentication, and customized security protocols made especially for Internet of Things gadgets. The suggested ideas provide workable and expandable implementations by balancing security and resource limitations. This research is important because it helps protect the integrity and confidentiality of sensitive data and strengthens the IoT ecosystem against any threats. The knowledge gathered from this study can direct future initiatives as the Internet of Things develops, providing a safe and reliable framework for the growing network.

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## Breast Cancer Detection Using Machine Learning Algorithms-A Survey

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### ABSTRACT

Breast Cancer is one of the most common cancers affecting the people of India. It is more occurred in women than men. Early diagnosis of cancer can reduce the mortality rate. There is different method are existed to detect the cancer at an early state. Using machine learning algorithms is one approach to identify breast cancer early. Finding a strong correlation between different characteristics and malignant tumours is made easier with the use of machine learning algorithms. In this paper mainly discussed the different algorithms like Support Vector Machine, Logistics Regression, Random Forest, Decision Tree etc to compare their accuracy and efficiency

**Keywords:** Support Vector Machine, Random Forest, Logistics Regression, Decision Tree

### INTRODUCTION

According to the Indian Council of Medical Research (ICMR), the number of cancer cases in India is expected to increase by 12 percent over the next five years. The four most prevalent types of cancer that affect Indians are oral, lung, cervical, and breast cancers. The development of abnormal growth in certain breast cells leads to breast cancer. These cells continue to multiply and divide more quickly than healthy cells do, resulting in the formation of a mass or lump. Through your breast, cells may travel your lymph nodes or other areas of your body. Typically, breast cancer (invasive ductal carcinoma) starts in the cells in the milk-producing ducts. Invasive lobular carcinoma, a type of breast cancer, can potentially start in the glandular tissue known as lobules, as well as in other cells or tissues inside the breast. There are 25 different types of breast cancer, such as inflammatory breast cancer, metastatic breast cancer, ductal carcinoma in situ, and invasive ductal carcinoma. The non-invasive cancer known as ductal carcinoma in situ (DCIS) is identified by abnormal cells in the breast milk duct lining. The



**Nithya Paul and Nagappan**

surrounding breast tissue has not been invaded by the normal cells, which are contained within the ducts. Ductal carcinoma in situ is very early cancer that is very curable, but if it's left untreated or undiscovered, it may spread into the surrounding breast tissue. When malignant cells that originated in the milk ducts spread to other parts of the breast tissue, it results in an invasive cancer known as invasive ductal carcinoma (IDC). Other body parts may potentially become infected with invasive cancer cells. It also called infiltrative ductal carcinoma sometimes. About 70–80% of all cases of breast cancer are IDC cases, making it the most prevalent kind of the disease. Additionally, men are most frequently affected by IDC breast cancer. The condition known as Lobular Carcinoma In Situ (LCIS) is characterized by the presence of abnormal cells in the breast lobules. There's no sign that the aberrant cells are moving outside the lobules and into the surrounding breast tissue. LCIS is very curable and seldom progresses to aggressive malignancy. But the chance of getting breast cancer in either breast rises if you have LCIS in one of them. Invasive breast cancer that starts in the breast's lobules, or milk glands, and moves to the normal tissue nearby. Additionally, it has the ability to spread to other body areas through the lymph and blood systems. The second most frequent kind of breast cancer is invasive lobular breast cancer. Invasive lobular carcinomas account for more than 10% of invasive breast cancer cases. Mammograms are useful and essential, but invasive lobular breast cancer is harder for them to detect than other forms of the disease. On a mammography, invasive lobular cancer is not usually visible. Breast cancer in Stage 4 also includes metastatic cancer. Other body parts have been affected by the cancer. Usually, this includes the brain, bones, liver, and lungs.

**Machine Learning Algorithms**

A group of supervised learning techniques called support vector machines (SUPPORT VECTOR MACHINES) are utilized in classification, regression, and outlier identification. The advantages of support vector machines are: Effective in high dimensional spaces. Still effective in cases where number of dimensions is greater than the number of samples. Support Vector Machine (SUPPORT VECTOR MACHINE) is a classifier which divides the datasets into classes to find a maximum marginal hyper plane (MMH) via the nearest data points. A machine learning classification technique called logistic regression is used to forecast the likelihood of particular classes depending on a set of dependent factors. To put it briefly, the logistic regression model adds up all of the input features (usually, there is bias term), then computes the outcome's logistic Overview Decision Trees are a kind of Supervised Machine Learning in which the training data is continually divided based on a given parameter. In other words, you describe what the input and corresponding output in the data are. A group of classification methods built on Bayes' Theorem is known as a naive bayes classifier. It is actually a family of algorithms rather than a single method, and they are all based on the same principle—that is, each pair of features being classified stands alone. Random forests, also known as random choice forests, are an ensemble technique for classification, regression, and other problems.

During training, a large number of decision trees are constructed, and the class that results is the mode of the classes. k-Nearest Neighbors (K-NN) is a supervised classification algorithm. It utilizes a large number of labeled points as training data to learn how to classify new points. The process of labeling a new point involves examining the labeled points that are closest to it, or its nearest neighbors. A distributed, scalable gradient-boosted decision tree (GBDT) machine learning system is called Extreme Gradient Boosting, or XGBoost. It is the best machine learning software with parallel tree boosting for problems with regression, classification, and ranking. An orthogonal transformation is used in Principal Component Analysis (PCA), a statistical technique, to turn a set of correlated variables into a set of uncorrelated variables. The most used tool in machine learning for prediction models and exploratory data analysis is principal component analysis (PCA). An appropriate smoothness property (e.g., differentiable or sub differentiable) for an objective function can be optimized iteratively using stochastic gradient descent, or SGD. Supervised learning formats use MLP networks. Back propagation's method is another name for a common MLP network learning process. A feed forward multilayer perceptron is a type of artificial neural network (ANN) that generates a set of outputs from an input collection (MLP).

**Literature Survey**

Junaid Rashid et al[1] proposed that the ensemble method, (SUPPORT VECTOR MACHINE+ LOGISTIC REGRESSION +NAIVE BAYES + DT) performs well without and with up sampling on the diagnosis dataset,



**Nithya Paul and Nagappan**

whereas(SUPPORT VECTOR MACHINE + LOGISTIC REGRESSION +RF + NAIVE BAYES) outperforms all other combinations on the prognosis dataset when ANN is used as a final layer. They also observed that ensemble method yields more accuracy than individual method. Manav Mangukiya, Anuj Vaghani, and Meet Savani [2] looked at thirty-one different machine learning methods for breast cancer diagnosis. Their study's goals were to analyze the Wisconsin breast cancer dataset through machine learning evaluation and visualization. Using this research paper, we can see that XGboost, with an efficiency of 98.24%, is the most accurate algorithm for the best accurate result for breast cancer detection, among Naïve Bayes, Support Vector Machine, Adaboost, Random Forest Classifier, K-NEAREST NEIGHBORS, Decision Tree, etc. The use of data mining techniques for the detection and prediction of breast malignant tumours was covered by V Chaurasia<sup>1</sup>, MK Pandey, and S Pal [3]. These techniques included random forest (RF), support vector classifier (SVC), k-nearest neighbors (K-NEAREST NEIGHBORS), linear discriminant analysis (LDA), gradient boosting classifier (GBC), and decision tree (DT) In addition, principal component analysis (PCA) to underline changes and show strong patterns in the informational index.

The degree to which qualities are closely related to one another is also demonstrated by the connection structure. The accuracy of a classifier with chosen features and the accuracy of a data set with all features are compared using the sequential feature selection (SFS) approach. The results reveal that RF\_sfs, K-NEAREST NEIGHBORS\_sfs, SVC\_rbf and SVC\_sfs have the highest and equal accuracy, which is 97.66%. Lihao Zhang *et al* [4] showed that Raman spectroscopy combined with PCA-DFA and PCA-SUPPORT VECTOR MACHINE machine learning algorithms was capable of identifying breast cancer cells and classifying cancer cell subtypes at a single-cell level. The PCA-DFA and PCA-SUPPORT VECTOR MACHINE models were applied to Raman spectral data processing, resulting in cancer cell diagnostic accuracies of 97.6% and 99.0%. Each cancer cell line's Raman spectrum data contains a wealth of biochemical information, and the machine learning results indicated that this information could be useful for making diagnoses. Thus, the combination of Raman spectroscopy and machine learning algorithms could potentially replace the slow and tedious cytological evaluations that are now performed in order to enhance clinical diagnosis. Viswanatha Reddy Allugunti [5], carried out an investigation into the similarities and differences between CNN, SUPPORT VECTOR MACHINE, and Random Forest.

It was discovered that CNN performs better than the other approaches that are currently in use in terms of accuracy, precision, and the amount of data that is used. The accuracy that was acquired by CNN was 99.67 percent, whereas the accuracy that was gained by SUPPORT VECTOR MACHINE was 89.84 percent, and the accuracy that was obtained by RF was 90.55 percent. Habib Benlahmard *et al* [6] applied five main algorithms which are: SUPPORT VECTOR MACHINE, Random Forests, Logistic Regression, Decision Tree and K-NN on the Wisconsin Breast Cancer Diagnostic dataset (WBCD) to calculate, compare and evaluate different results obtained based on confusion matrix, accuracy, sensitivity, precision, AUC to identify the best machine learning algorithm that are precise, reliable and find the higher accuracy. Python has been used to program each algorithm, with the Scikit-Learn package in the Anaconda environment. Following a precise model-to-model comparison, it was discovered that the Support Vector Machine surpasses all other techniques and achieves greater efficiency (97.2%), precision (97.5%), and AUC (96.6%). In summary, Support Vector Machine has proven to be effective in both diagnosing and predicting breast cancer, achieving the highest levels of precision and accuracy.

Shafaq Abbaset *al* [7]proposed a novel approach named BCD-WERT is proposed that utilizes WOA andExtra Randomized Tree (ERT) algorithm for the detection of breast cancer. In order to extract the best features from the dataset and remove any extraneous information, WOA-based feature selection is used. The ERT classifier and other algorithms receive this as input.For classification, further methods include DT, K-NEAREST NEIGHBORS, SGD, RF, LOGISTIC REGRESSION, KSUPPORT VECTOR MACHINE, GNAIVE BAYES, and SUPPORT VECTOR MACHINE. Performance is contrasted with BCD-WERT. The results demonstrated that, when used the WOA and ERT classifier, BCD-WERT obtained the greatest accuracy rate of 99.03%. Taarun Srinivas *et al* span class='highlighted color-8'>span>, using 20 different ML classification algorithms were trained on a Breast Cancer dataset from the University of Wisconsin to detect the same. According to the results, SGD produced the greatest accuracy (98%), while BNAIVE BAYES produced the lowest accuracy (63%).



**Nithya Paul and Nagappan**

Nidhi Mangoriya and Vinod Patel [9] done a classification of the features that are extracted takes place through Naïve Bayes, SUPPORT VECTOR MACHINE and hybrid algorithms. Hybrid algorithms is considered as efficient algorithm as a set of weak classifiers are selected and are combined into a final strong classifier. Results show that the classification accuracy of hybrid algorithms classifier performs better than naïve bayes Karl Hall, Victor Chang and Paul Mitchell [10] proposed SUPPORT VECTOR MACHINE algorithms traditionally perform very well at binary classification problems with pre-labelled data. Random Forest, XGBoost, Light GMB and Cat Boost are examples of increasingly popular algorithms that can be utilized for handling classification problems. Multiple models are integrated simultaneously and often achieve better performance than singular models. Several well-known machine learning techniques were employed by Mohammad Monirujjaman et al. [11]. The algorithms with the greatest F1-scores were logistic regression, random forest, decision tree, and K-nearest neighbor, with respective percentages of 96%, 95%, 90%, and 98%. S. Dalal *et al* [12] studied the machine learning algorithms and obtained the accuracy as follows. Random tree classification 95%, MLP 98.6% Logistic regression 99.12%, XGBoost tree 99.47% and Ensemble model 99.69%.

**CONCLUSION**

It is possible to accurately diagnose breast cancer by using machine learning algorithms. The Wisconsin Breast Cancer Dataset is one of the reliable datasets for training machine learning models. Machine learning algorithms are a valuable tool for breast cancer prediction, as evidenced by the fact that six out of the algorithms that have been used have provided prediction accuracy of over 90.0%.

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**Nithya Paul and Nagappan**

References	Algorithms used	Accuracy
[1]	SUPPORT VECTOR MACHINE + LOGISTIC REGRESSION +NAIVE BAYES + Decision Tree	97.67%
	SUPPORT VECTOR MACHINE + LOGISTIC REGRESSION + Random Forest + NAIVE BAYES	97.07%
[2]	XGboost	98.24%.
[3]	Random Forest, K-NEAREST NEIGHBORS, SVC and SVC_sfs	97.66%.
[4]	PCA–DFA model	97.6%
	PCA–SUPPORT VECTOR MACHINE model	99.0%
[5]	CNN	99.67%
	SUPPORT VECTOR MACHINE	89.84%
	RF	90.55%
[6]	Support Vector Machine	97.2%
[7]	BCD-WERT	99.03%
[8]	SGD	98.0%
[9]	Hybrid algorithm	97.0%
[10]	SUPPORT VECTOR MACHINE-RBF	99.0%
[11]	Random forest	96.0%
	decision tree	95.0%
	K-nearest neighbor	90.0%
	logistic regression	98.0%
[12]	Random tree classification	95.0%
	MLP	98.6%
	Logistic regression	99.12%
	XGBoost tree	99.47%
	Ensemble model	99.69%





# The Impact of Women Empowerment on Sustainable Development

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## ABSTRACT

Women empowerment and economic development are closely related: in one direction, development alone can play a major role in driving down inequality between men and women; in the other direction, empowering women may benefit development. Does this imply that pushing just one of these two levers would set a virtuous circle in motion? This paper reviews the literature on both sides of the empowerment-development nexus, and argues that the inter-relationships are probably too weak to be self-sustaining, and that continuous policy commitment to equality for its own sake may be needed to bring about equality between men and women. This paper focuses on women's empowerment as a key process in reaching gender equality and, through that, sustainable development. It first discusses the concepts of women's empowerment and sustainable development and shows how both are inter-linked through the lens of intra and inter-generational justice.

**Keywords:** women empowerment, Sustainable development, gender equality.

## INTRODUCTION

One of the primary focuses of foreign aid is on empowering women. A fair and equitable distribution of resources is essential for present and future sustainable development. Promoting fundamental women's rights on an equity and partnership basis is central to achieving sustainable development. Empowering women is essential to long-term economic growth, social justice, and environmental stability (Baker, 2006). Women are the primary focus in the three areas of sustainable development in third world countries: environmental protection, economic prosperity, and social justice. Regarding the environmental pillar, it is argued that women are instrumental in promoting sustainable development patterns in natural resource management due to their domestic, agricultural, and cultural roles and their knowledge of the local environment. In the SD pillar of economic well-being, it is widely acknowledged that economic well-being cannot be achieved if one group is massively underprivileged compared to the other and if all members of society are underutilizing their skills. The persistence of gender inequality is most starkly brought home in the phenomenon of "missing women". The term was coined by Amartya Sen in a now





**Remya Cheriyan and Kavitha Vincent**

classic article in the New York Review of Books (Sen, 1990) to capture the fact that the proportion of women is lower than what would be expected if girls and women throughout the developing world were born and died at the same rate, relative to boys and men, as they do in Sub Saharan Africa. Today, it is estimated that 6 million women are missing every year (World Development Report, 2012) Of these, 23 percent are never born, 10 percent are missing in early childhood, 21 percent in the reproductive years, and 38 percent above the age of 60. Stark as the excess mortality is, it still does not capture the fact that throughout their lives, even before birth, women in developing countries are treated differently than their brothers, lagging behind men in many domains Regarding the pillar of social equity, the connection between gender equity and social equity and the widespread acceptance that discrimination against any one social group makes it impossible for any society to survive and live in dignity in the long run are essential. Equal rights for women are a priority for the World Bank's aid programmes. This concept was developed on the grounds that empowering women is a means to an end, and that social justice is an essential part of human welfare that is basically worth pursuing. The present study is a significant attempt to examine the impact of women's empowerment on sustainable development, which has been the subject of scant prior research .This empowerment takes many forms, including women's increased agency in the home and political participation, as well as greater control over their own and their children's health care.

**Objective**

1. To understand the importance of accelerating the pace of change in women's development
2. To study the role and importance of women empowerment for a sustainable future

**RESEARCH METHODOLOGY****Scope of Study**

Women are an integral part of every economy. All round development and harmonious growth of a nation would be possible only when women are considered as equal partners in progress with men. Women empowerment is of utmost significance in order to achieve a lasting and sustainable development of society. This study provides an insight to the current scenario as well as the future trends which may follow.

**Types of Research**

It is the framework for conducting the research project. The research design used here is Descriptive Research Design which is used for description of something. For this purpose, **Secondary Data** collected through: Internet and web search, Newspaper and magazines

**LITERATURE REVIEW**

Although international agencies have long legitimized the concept of women's empowerment what constitutes empowerment and how it is measured are still hotly contested topics in the development literature. By defining women's empowerment as the "process of the expansion of ability to make strategic life choices in a context where this ability was previously denied," Kabeer's (2001) "Resources, Agency, Achievements: Reflections on the Measurement of Women's Empowerment" provides a crucial definition. The research detailed the three interconnected facets of empowerment: access to resources, agency, and accomplishments. Empowering women is a complex and multifaceted idea. Women's empowerment has been measured in various ways across studies (Malhotra and Mather, 1997; Mason, 1998; Jejeebhoy, 2000; Jejeebhoy and Sather, 2001; Chaudhry and Nosheen, 2009; Iram Naz *et al.*, 2010), with mobility, household decision power, access to resources, and control over resources being the most common. In addition, "women may be empowered in one dimension of life and not in another," as several studies have shown (Malhotra *et al.*, 2003; Kishore and Gupta, 2004). Research by Naqvi and Shahnaz (2002) found that where a woman lives has a major impact on her ability to make decisions about her own life. The Female Liberation and Freedom Plan (FLFP) is widely considered a crucial factor in advancing



**Remya Cheriyan and Kavitha Vincent**

women's equality (Ashraf and Ashraf, 1993 in estimating "the gender wage gap in Rawalpindi"; Azidet *et al.*, 2001 in analyzing the "Poverty, FLFP and cottage industry"; Ejaz, 2007). Jameel's (2011) "Women's empowerment and economic development" explored the two-way connection between women's independence and monetary growth. Both development and women's empowerment can help close the gender gap. This paper examined the research on both sides of the empowerment-development nexus and concluded that the links are not strong enough to maintain themselves and that a sustained effort on the part of policymakers is required to finally bring about gender parity. Research by Zahir *et al.* (2009), titled "The Socio-Economic and Demographic Determinants of Women's Work Participation in Pakistan: Evidence from Bahawalpur District," examines the various socio-economic and demographic factors that influence women's labor force participation. The 164 participants were spread across both urban and rural Bahawalpur locations. Women's education was found to be a key factor in the study's conclusion that women are under represented in the workforce. It is undeniable that women have made significant contributions to human progress.

Male youth's perspective on women's integration participation is crucial if they are to become active participants in development. Absolute and relative disempowerment of women compared to men in India was also found in the study "Women's empowerment in India and its states: evidence from NFHs" by Kishore and Gupta (2004). They used two sets of indicators: one focused on women's beliefs about gender equality and the other on their level of environmental agency. Participation in household decision-making and mobility were used as indicators of women's sense of agency. Desai examined "the conceptual and methodological issues" of W.E. in her paper "Human Development Research Paper 2010/14: Hope in Hard Times: Women's Empowerment and Human Development." Women's economic and political participation, as well as their access to quality education and healthcare, were also examined over the course of the study's 20-year time frame. Conceptual issues addressed the expanding agreement that women's empowerment is both a process and an outcome; that is, that it is the exercise of one's own discretionary power over one's own resources. Murphy (2012) argues that a better understanding of the social pillar of sustainable development is preferable, and he explains why W.E. and equity are essential tools for its achievement in his article "The Social Pillar of Sustainable Development: a Literature Review and Framework for Policy Analysis." This study fills a gap in the literature by examining the primary factors that contribute to women's empowerment in the extremely underdeveloped and impoverished regions of Sargodha, where they are still socially excluded, vulnerable, and oppressed. The role of women's empowerment in achieving sustainable development is also barely explored in the academic literature.

## DISCUSSION

To successfully empower women, both gender and empowerment concerns should be integrated into every service provision area. Moreover, they should be incorporated in the economic, political and social spheres as well as at the individual, household and community levels in order to overcome gender inequality and achieve sustainable development. Economic empowerment provides incentives to change the patterns of traditional behavior to which a woman is bound as a dependent member of the household. *Women's economic empowerment* sets a direct path towards gender equality, poverty eradication and inclusive economic growth that significantly contributes to advancing women empowerment and *sustainable development*. Social empowerment of women supports the promotion of gender equality. Gender equality implies a society in which women enjoy the same opportunities, outcomes, rights and obligations in all spheres of life which helps in sustainable development. Political Empowerment favors the participation in and control by the women of the political decision-making process and in governance. Women's political empowerment provides access to resources, rights, and entitlements through decision-making powers and due position in governance which gives a significant boost to the position of sustainable development. Individually women do not have the self-confidence to articulate and assert the power to negotiate and decide. At household level Women were denied the right to education and widow remarriage. They were also denied the right to inheritance and ownership of property. At community level a strong patriarchy society with deep-rooted socio-cultural values continues to affect women's empowerment. Women share the



**Remya Cheriyan and Kavitha Vincent**

primary responsibility for nutrition, child care and household management in almost all countries. They are also active in environmental management. Yet, despite their roles, women are not adequately represented in the decision-making processes related to the issues of environment and development at local, national or international levels. To overcome from these issues, on the one hand women's empowerment needs the building of an enabling environment for the implementation of women's human rights and on the other hand it needs the enhancement of women's skills and capacities as active agents of change for sustainable development.

**Findings**

The centrality of gender equality has also been articulated in the outcome document of the United Nations Conference on Sustainable Development, entitled "The future we want", adopted in 2012, which included recognition of the importance of gender equality and women's empowerment across the three pillars of sustainable development, economic, social and environmental, and resolve to promote gender equality and women's full participation in sustainable development policies, programs and decision-making at all levels. Sustainable development cannot be achieved without a more impartial dispensation of resources today and tomorrow. Minimizing the imbalance is an important condition in "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Economic, social and environmental affair need to be commenced in an integrated and aggregate manner. From a gender outlook, it is particularly necessary not to concede gender equality as a socio-cultural concern but to give it due attention in the economic and environmental domain as well – treating gender equality as a crosscutting target. Demographic, political and economic changes are the internal factors behind the growth of women organizations.

The empowerment occurs when women achieve increased control and participation in decision making that leads to their better access to resources, and therefore, improved social and economic status. There can be identified five levels of empowerment, namely, welfare, access to resources and services, forming groups for defending interests, mobilization of efforts and control over decision-making process While aiming to maximize the well-being of today's generation, it is important to take a long-term perspective, taking into account the consequences of our actions for our children, their children and grandchildren, ensuring that the resources they will require for their own well-being are not depleted, and that the natural environment into which they will be born will not be polluted or destroyed. Women's contribution to sustainable development, and their skills and ability, must be acknowledged. Women have a strong role in nurturing, educating and socializing their children, including teaching them care, protection and responsibility with regard to the use and protection of natural resources. Taking women's needs, concerns and their knowledge and skills into account will ensure a better understanding of the dynamics in society which create and perpetuate gender inequality and enable policymakers and other agents of change, including employers and civil society organizations, to develop appropriate policy responses and actions. Equally taking part in decision-making and a uniform involvement of both gender at all levels of execution will ensure that women take equal responsibility as men for today's and future generations.

**Suggestions**

Attaining development among all the pillars of sustainable development is unthinkable without empowering women and obtaining gender equality. Government needs to work hard to change the existing position of women and achieve gender equality, which will have a positive spillover effect on the sustainable development of the country.

1. Empowering women and making full use of their labor force for economic growth.
2. Educating and maintaining the health of women to enhance productivity and social development.
3. Empowering women and providing them with fair representation across different decision-making levels of the government structure to better protect women's interests and to achieve quality governance.
4. Protecting the rights of women to make them active participants in the economic, social, political, cultural, and other arenas thereby bringing about development.

Empowering women to play an equal role in the protection and management of the environment as the environment



**Remya Cheriyan and Kavitha Vincent**

is the key source of the country's economy with their special knowledge and expertise.

**CONCLUSION**

Women empowerment is not just a lofty aspiration anymore; it is the necessary missing link for sustainable development. Women, on average, reinvest up to 90% of income into their households. Reducing gender inequality gives women more money to spend on food, housing and education – crucial components for reducing poverty and promoting sustainable development. Women's empowerment is important for sustainable development and common future. Reaffirm the commitments to ensure women's equal rights, access and opportunities for participation and leadership in the economy, society and political decision-making. Women should be empowered and gender equality needs to be assured if sustainable development is to succeed. If women can't actively participate in society, half of the world's population is left aside. So for the societies to be successful, we need women's empowerment, gender equality and protection of sexual and reproductive rights. This way we can enhance sustainable development

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# Advancing Osteosarcoma Detection in Histopathology Images through Weighted Bilateral Filtering, Parabolic Balance Contrast Enhancement, and Morphological Operations

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## ABSTRACT

Osteosarcoma, kind of cancer that begins in the cells that form bones, poses a significant health challenge requiring early and accurate detection for effective treatment. This research investigates the synergistic application of advanced preprocessing techniques—weighted bilateral filtering, Parabolic Balance Contrast Enhancement (PCBE), and morphological operations—to enhance osteosarcoma detection in histopathology images. Histopathology images, crucial for diagnosing osteosarcoma, often suffer from inherent challenges such as noise and low contrast. To address these issues, we explore novel preprocessing approaches. Weighted bilateral filtering is employed to preserve image structures while reducing noise, PCBE enhances contrast through a parabolic balance approach, and morphological operations such as dilation and erosion refine image structures. This research demonstrates that the integration of weighted bilateral filtering, PCBE, and morphological operations significantly advances osteosarcoma detection in histopathology images. These findings underscore the potential for improved clinical outcomes through the implementation of advanced preprocessing techniques in osteosarcoma diagnosis. The proposed study used a PYTHON tool for implementation, and the dataset is publicly accessible online histopathological images. The proposed scheme is evaluated using accuracy, specificity, sensitivity.

**Keywords:** Weighted bilateral filtering, Parabolic Balance Contrast Enhancement, Dilation, Erosion, Filtering, Histopathology images





**Deepak and Bharanidharan**

## INTRODUCTION

Osteosarcoma, a malignancy that arises from the bones, presents a pressing challenge in the field of oncology, demanding not only clinical expertise but also innovative solutions for early detection. The importance of accurate and timely diagnosis cannot be overstated, and in the era of digital pathology, histopathology images stand as crucial diagnostic aids. This research endeavors to pioneer a groundbreaking approach to enhance osteosarcoma detection in histopathological images through the fusion of advanced image processing techniques. Traditional diagnostic methods often face limitations in capturing the complex structures and abnormalities inherent in osteosarcoma tissues. In response to this challenge, our study introduces a novel methodology designed to unravel the complexity of osteosarcoma detection. The initial step in our methodology employs weighted bilateral filtering to strike a delicate balance between preserving crucial edges and structures while effectively suppressing noise. This process not only ensures the fidelity of essential features but also lays a foundation for subsequent stages of analysis. In response to the intricacies of tissue textures and subtle variations within the images, our methodology incorporates parabolic balance contrast enhancement. This technique goes beyond traditional contrast enhancement methods, refining the visibility of potential osteosarcoma lesions and harmonizing contrasts. The result is an enriched representation, enabling a more nuanced and comprehensive understanding of the histopathological landscape. The methodology is further enriched through the integration of morphological operations. These operations play a pivotal role in fine-tuning the image, isolating suspicious regions, and enhancing structural information. By employing erosion and dilation strategically, we aim to refine the details necessary for precise osteosarcoma detection. This research stands at the intersection of medical imaging and computational methodologies, offering a promising avenue for improving osteosarcoma diagnosis. By exploring the synergies between weighted bilateral filtering, parabolic balance contrast enhancement, and morphological operations, we anticipate not only advancing the scientific understanding of osteosarcoma but also contributing to the growth of more precise and effective diagnostic tools. In the subsequent sections of this paper, we will explain into the detailed methodology, experimental setup, and results, presenting a comprehensive analysis of the proposed approach with some other methods.

## LITERATURE REVIEW

Sweety Deswal, Shailender Gupta and Bharat Bhushan [1] various types of bilateral filtering and types are being reviewed and analyzed on account of performance matrices. In order to remove mixed types of noise they adopt Switching Bilateral Filter. For the removal of impulse noise they used Modified Double Bilateral Filter and for the removal of Gaussian noise they used Joint Bilateral Filter. C. Tomasi, R. Manduchi [4] uses a non-iterative method for edge preserving smoothing. They use the concept of domain filtering. It combines gray levels or colors on geometric closeness and photometric similarity and bilateral filtering produces no phantom colors along edges in color images, and reduces phantom colors where they appear in the original image. P M Narendra [6] numerous properties of the separate filter that are produced when a one-dimensional median filter is applied repeatedly to an image's rows and columns are examined. This separable filter performs similarly to noise smoothing in images, despite having a somewhat different output from the analogous non separable two-dimensional median filter with a square window. Specifically, its noise-smoothing efficiency and edge-related behavior are described and contrasted with the two-dimensional median filters. Qingxiong Yang, Kar Han Tan, Narendra Ahuja [7] Remove shadows from a single image using color information. They derive a 2-D image based on colors and then use bilateral filtering to recover a 3-D image. Reduces contrast in areas with similar surface reflectance the derived image has incorrect luminance values. To correct this, they decompose the input image and the derived image as base and detail layers. They then combine the base layer from the input image and form detail layer from the derived image to create a shadow-free image with accurate luminance values.





**Deepak and Bharanidharan****Motivation**

The motivation behind this research stems from the critical need for improved diagnostic methodologies in the realm of osteosarcoma, a malignancy that poses substantial challenges to accurate detection and characterization. Osteosarcoma's intricate histopathological nature demands an innovative approach, necessitating a departure from conventional diagnostic strategies. The amalgamation of weighted bilateral filtering, parabolic balance contrast enhancement, and morphological operations is motivated by Diagnostic Complexity of Osteosarcoma, Clinical Implications of Early Detection, Technological Advancements in Image Processing, and Translational Impact on Clinical Practice. In essence, our motivation is a fusion of scientific curiosity, a commitment to addressing clinical challenges, and a profound desire to make a positive impact on patient outcomes. Through the amalgamation of cutting-edge image processing techniques, we aspire to usher in a new era of precision in osteosarcoma detection, influencing both the scientific community and the everyday practice of healthcare professionals.

**PROPOSED METHODOLOGY**

This section explains methodology of pre-processing such as weighted bilateral filtering for noise removal, parabolic contrast balance enhancement for image enhancement and morphology operations such as dilation and erosion for eliminating unwanted portions of the input image. Our paper mainly focused on these pre-processing technique.

**Performance Measures**

Histopathology Images through Weighted Bilateral Filtering, Parabolic Balance Contrast Enhancement, and Morphological Operations would depend on the objectives of the study and the specific tasks involved in osteosarcoma detection. Generally, in medical image processing and analysis, several metrics are commonly used to evaluate the performance of algorithms

**Sensitivity (True Positive Rate or Recall)**

Sensitivity measures the proportion of actual positive cases correctly identified by the algorithm. It's calculated as  $TP / (TP + FN)$ , where TP is the number of true positives, and FN is the number of false negatives.

**Specificity (True Negative Rate)**

Specificity measures the proportion of actual negative cases correctly identified by the algorithm. It's calculated as  $TN / (TN + FP)$ , where TN is the number of true negatives, and FP is the number of false positives.

**Accuracy**

An algorithm's accuracy indicates how correct it is overall. It's calculated as  $(TP + TN) / (TP + TN + FP + FN)$ .

**F1 Score**

The F1 score is the harmonic mean of precision and sensitivity. It's calculated as  $2 * (Precision * Sensitivity) / (Precision + Sensitivity)$ .

**Area under the ROC Curve (AUC-ROC)**

AUC-ROC measures the ability of the algorithm to discriminate between positive and negative cases across different thresholds.

**CONCLUSION**

In this paper, I presented comparative study of various filtering techniques for noise removal to detect osteosarcoma in histopathology images. Each filter has properties of its own. Depending on the type of noise, the proper filter is selected and the amount of filtering necessary. Here weighted bilateral filtering is used for noise removal, Parabolic Balance Contrast Enhancement is used for image enhancement and enhance contrast and Morphological Operations such as dilation and erosion is used for removing unwanted portions and thereby structure enhancement. Thus the proposed scheme showed its dominance in all the cases. In this work, pre-processing is only done for improving the image quality for better correctness in osteosarcoma detection.





### Deepak and Bharanidharan

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## WEIGHTED BILATERAL FILTERING

Algorithm 1: Image Processing with Weighted Bilateral Filtering
Input: image
Output: filtered image
1. Set the image path
2. Read the image
3. Convert the image to grayscale
4. Display and save the original image
5. Apply Weighted Bilateral Filtering
Set parameters: spatial_sigma = 10, range_sigma_color = 100, range_sigma_space = 100





**Deepak and Bharanidharan**

Weighted bilateral = Weighted bilateral(image, spatial\_sigma, range\_sigma\_color, range\_sigma\_space)  
 6. Display and save the filtered image

**Parabolic Balance Contrast Enhancement**

**Algorithm 2: Parabolic Balance Contrast Enhancement (PBCE)**  
 Input: Weighted Bilateral Filtered Image (WeightedBilateral\_)  
 Apply Parabolic Balance Contrast Enhancement:  
 - Create an instance of PBCE: parabalconenc = PBCE(WeightedBilateral\_)  
 Display and save the enhanced image  
 Input: Grayscale Image (img)  
 1. Compute image statistics in the input image:  
 - Lmin = Minimum pixel value  
 - Lmax = Maximum pixel value  
 - Lmean = Mean pixel value  
 - LMssum = Mean square sum  
 2. Define output image range:  
 - Gmin = 0  
 - Gmax = 255  
 - Gmean = 110  
 3. Calculate parameters for the parabolic function:  
 - bnum = ((Lmax<sup>2</sup> \* (Gmean - Gmin)) - (LMssum \* (Gmax - Gmin)) + ((Lmin<sup>2</sup>) \* (Gmax - Gmean))  
 - bden = 2 \* (Lmax \* (Gmean - Gmin) - Lmean \* (Gmax - Gmin) + Lmin \* (Gmax - Gmean))  
 - b = bnum / bden  
 - a = (Gmax - Gmin) / ((Lmax - Lmin) \* (Lmax + Lmin - 2 \* b))  
 - c = Gmin - a \* (Lmin - b) \* (Lmin - b)  
 4. Apply the parabolic function to enhance contrast:  
 - y = a \* (img - b) \* (img - b) + c  
 5. Clip values to the valid range [0, 255]:  
 - y = clip(y, 0, 255)  
 6. Output: Enhanced Image (y)

**Morphological Operations**

**Algorithm 3: Erosion and Dilation (Morphological Process)**  
 Input: Grayscale Image (parabalconenc)  
 1. Define a morphological kernel:  
 2. Perform Erosion  
 3. Display and save the eroded image  
 4. Perform Dilation on the eroded image  
 5. Display and save the dilated image

**Table 1 represents a study of Weighted bilateral filtering, Parabolic Balance Contrast Enhancement and Morphological Operations**

Aspect	Weighted Bilateral Filtering	Parabolic Balance Contrast Enhancement	Morphological Operations
<b>Objective</b>	Improve osteosarcoma detection in histopathology images	Enhance contrast using parabolic balance	Employ morphological operations





**Deepak and Bharanidharan**

<b>Methodology</b>	Weighted Bilateral Filtering applied to histopathology images	Parabolic Balance Contrast Enhancement applied to pre-processed images	Morphological operations (erosion and dilation) on enhanced images
<b>Image Enhancement</b>	Preserves edges and reduces noise	Improves contrast using parabolic function	Morphological operations for structure enhancement
<b>Evaluation Metrics</b>	Sensitivity, Specificity, Accuracy	F1 Score, AUC-ROC	Sensitivity, Specificity
<b>Results</b>	Quantitative improvement in osteosarcoma detection	Enhanced contrast and improved visual quality	Improved structure representation
<b>Limitations</b>	Sensitivity to parameter selection	Sensitivity to initial image quality	Sensitivity to image variations
<b>Advantages</b>	Edge preservation, noise reduction	Improved contrast without losing details	Structural enhancement
<b>Applications</b>	Histopathology image analysis	Image enhancement in various medical imaging scenarios	Image preprocessing for further analysis
<b>Future Directions</b>	Optimization of parameter selection	Integration with deep learning methods	Exploration of advanced morphological techniques

**Table 2 Comparative study of various types of filters for noise removal**

Aspect	Gaussian Filter	Median Filter	Bilateral Filter	Weighted Bilateral Filter	Wiener Filter
<b>Objective</b>	Smoothing, noise reduction	Noise reduction, edge preservation	Edge-preserving smoothing	Edge-preserving smoothing	Additive noise reduction
<b>Strengths</b>	Simplicity, effective for Gaussian noise	Robust to impulse noise, edge preservation	Edge preservation, noise reduction	Improved edge preservation, noise reduction	Adaptability, noise reduction
<b>Weaknesses</b>	Limited edge preservation	May blur fine details, less effective for Gaussian noise	Computationally expensive, sensitivity to parameters	Sensitivity to parameter tuning	Assumes linear noise model
<b>Applications</b>	General smoothing, Gaussian noise reduction	Salt-and-pepper noise reduction, edge-preserving smoothing	Image denoising with edge preservation	Edge-preserving smoothing, noise reduction	Restoration of images with additive noise
<b>Computational Complexity</b>	Low	Low to moderate	Moderate to high	Moderate to high	Moderate to high
<b>Parameter Sensitivity</b>	Low	Moderate	Moderate to high	Moderate	Moderate

**Table 3 represents evaluation metrics of various types of filters for osteosarcoma detection.**

Filter	Accuracy	Sensitivity	Specificity
<b>Gaussian Filter</b>	Moderate	Moderate	Moderate
<b>Median Filter</b>	Moderate	High	High
<b>Bilateral Filter</b>	Moderate to High	High	High
<b>Weighted Bilateral Filter</b>	High	High	High
<b>Wiener Filter</b>	High	Moderate to High	Moderate to High





Deepak and Bharanidharan

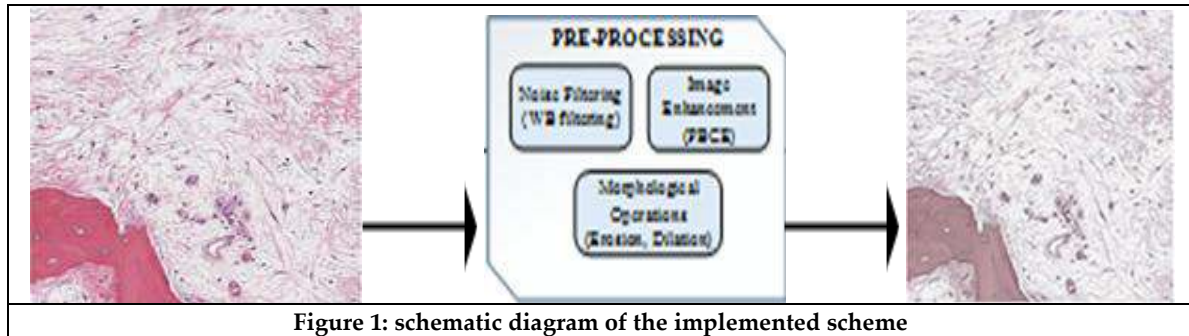


Figure 1: schematic diagram of the implemented scheme





## Unveiling Determinants of Consumer Intent in Green Purchasing

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### ABSTRACT

In the face of escalating environmental concerns, businesses globally are increasingly adopting green marketing strategies. This study delves into the intricate dynamics that shape consumer's intention to purchase green products, with a specific focus on the Indian market. The research investigates various factors influencing green purchase behavior, including personal values, motivation, packaging, and information available at the point of sale. As environmentalism becomes a worldwide phenomenon, the awareness of green marketing practices among Indian consumers has grown significantly. Many manufacturers in India are embracing green marketing, aligning their products and services with environmentally sustainable practices. This study aims to contribute to the understanding of consumer behavior in the context of green purchasing, shedding light on the factors that play a crucial role in shaping consumer's intentions.

**Keywords:** Green Marketing, Consumer Intent, Sustainable Practices, Eco-Friendly Products, Green Purchase Behavior, Green Marketing Practices.

## INTRODUCTION

Environmentalism in marketing reflects the increasing awareness and commitment to protecting and enhancing the environment in the realm of business. This entails businesses integrating environmental considerations into their product design and service offerings. Peattie (1995) provides a comprehensive definition, characterizing green marketing as a holistic management process that identifies, anticipates, and satisfies customer and societal needs in a profitable and sustainable manner. The global emergence of environmentalism has prompted marketing organizations to respond to environmental challenges by adopting green marketing strategies. Green marketing involves planning, developing, and promoting environmentally friendly products or services that meet customer's needs without causing negative effects on the environment. In the face of mounting awareness about global warming, non-biodegradable waste, and pollution, both marketers and consumers are recognizing the importance of





**Chinnu Mohanan and Antony George**

transitioning to green products and services. While this shift may appear costly initially, it proves to be crucial, beneficial, and cost-effective in the long run. The strategy brings multiple benefits, including increased revenue, cost reduction, new product development, risk mitigation, environmental protection, global safety, and enhanced brand reputation. This shift is imperative to address environmental issues that affect human society and the natural atmosphere. Consumers, particularly those inclined toward green and eco-friendly choices, evaluate the impact of their activities on the market, manufacturing processes, and goods consumption. However, not all consumers exhibit the same degree of greenness, and their willingness to purchase green products varies. Green consumption signifies individual's efforts to protect the environment through decisions to purchase, reflecting a social responsibility rather than a legal obligation imposed by governments and societies. Demographic variables such as age, gender, education level, income, and the presence of children in households contribute to this consumer diversity. Non-demographic variables like willingness to pay, taste, nutritional value, environmental concern, and organic certification also influence consumer decisions when purchasing organic products.

**REVIEW OF LITERATURE**

Varah et al. (2021) investigated young Indian consumer's intention towards green products, proposing an extended Theory of Planned Behavior model with Willingness to Pay Premium and environmental Concern. Their findings revealed a significant relationship between the predictors, emphasizing the influence of these factors on purchase intention, particularly noting the need for a nuanced pricing strategy due to reported price sensitivity among Indian youth. Rausch & Kopplin, (2021), sustainable clothing purchase intention is highly impacted by attitude towards sustainable clothing and green washing has negative impact on purchase intention. Perceived aesthetic risk also negatively impacts intention and perceived economic risk has no impact on this relationship. Basha & Lal (2019) explored factors influencing consumer purchase intentions for organic foods in Chennai and Bengaluru, finding that environmentally conscious consumers expressed a willingness to pay a premium for such products. This finding is particularly relevant in the context of India, where agricultural activities hold significance among households, and it gains added importance in cities like Chennai and Bengaluru facing high environmental pollution. Zaidi et al. (2019), found that green trust acts as a crucial mediator between consumption values and green purchase intention, influenced by functional values such as quality and price, along with significant social values. The moderating impact of green washing perception on the relationship between consumption value and green trust underscores the pivotal role of green trust in driving green purchase intention, emphasizing the need for firms to prioritize efforts in enhancing consumer trust in green products.

**Statement of the Problem**

The symbiotic relationship between a country's economic well-being and its growth often comes at the cost of adverse environmental consequences such as global warming, resource depletion, and air pollution. Scholars and practitioners worldwide must proactively address the escalating environmental issues by embracing sustainable development practices to mitigate the detrimental impact of unplanned progress on both the environment and society. In this context, both eco innovation and green purchasing emerge as crucial components in fostering sustainable environmental development. Eco innovation involves the integration of environmental sustainability throughout the entire lifecycle of goods and services, resulting in reduced resource consumption during production and conferring a competitive advantage (Veleva and Ellen Becker, 2001; Paradowska and Platje, 2015). Conversely, green purchasing revolves around the conscious procurement of environmentally friendly goods while avoiding products that pose harm to the environment and animals (Schaefer and Crane, 2005).

**METHODOLOGY**

The research methodology employed in this study aims to systematically address the management problem of understanding the determinants of consumer intent in green purchasing. The process involves collecting and



**Chinnu Mohanan and Antony George**

analyzing data to inform business decisions. The researcher utilizes a comprehensive approach, encompassing research design, questionnaire design, data collection, and statistical tools for data analysis.

**Research Design** The chosen research design for this study is descriptive research, specifically utilized to depict the characteristics of the population or phenomenon under investigation. Descriptive research provides a framework to answer key research questions by collecting and analyzing relevant variables.

**Sources of Data** Both primary and secondary data sources are employed in this study. Primary Data was Collected directly from consumers through questionnaires distributed via Google Forms. This method involves interviews, surveys, and experiments, ensuring firsthand information directly from the source. Secondary Data was gathered from journals, websites, articles, and published records, offering additional context and supporting information beyond the primary data collected.

**Sample Design** The sample design outlines the specific measurements to be taken, the timing, materials, manner, and the selection of respondents. Key aspects of the sample design include:

**Population** Focuses on customers purchasing green products in Ernakulam district, providing a targeted subset for analysis.

**Sample Size** With a confidence level of 90%, a sample size of 120 respondents is chosen, allowing for a representative snapshot of the population.

**Sampling Technique** Convenience sampling is employed, a non-probability technique where respondents are selected based on their convenient availability. This approach aligns with the study's focus on judgment-based sampling.

**Data Collection Method** The data collection method involves distributing questionnaires through Google Forms to customers residing in the Cochin region. Using email and Whats App, participants were requested to fill and share the questionnaire within the Ernakulam District. The data collected is subsequently analyzed using IBM SPSS Statistics software to derive meaningful insights into the determinants of consumer intent in green purchasing.

**Objectives**

1. Investigate the extent of consumer awareness regarding the adoption of green products in the market.
2. Explore the correlation between customer awareness and satisfaction concerning green products.
3. Identify and analyze the diverse factors influencing customer intentions to engage in the purchase of green products.
4. Assess the level of customer satisfaction and its impact on fostering customer loyalty towards green products.

**Hypothesis of the Study**

- H1. Personal value is positively related to purchase intention
- H2. Motivation is positively related to purchase intention
- H3. Packaging is positively related to purchase intention
- H4. Information at the outlet is positively related to purchase intention
- H5. Customer satisfaction is positively related to customer loyalty

**Data Analysis** In this study, various statistical methods such as frequency analysis, correlation analysis, and regression analysis were employed to understand consumer behavior towards green products.

**Frequency Analysis****Demographic Overview**

In the studied sample of 120 respondents, 51.7% are males, while 48.3% are females. The majority of participants, constituting 77.5%, belong to the age group up to 25 years. Regarding education, a significant portion of respondents are postgraduates (56.7%), followed by graduates (27.5%), and professionals (8.3%). In terms of occupation, a substantial 59.2% identify as students, and 28.3% are employed in the private sector. Concerning monthly income, a noteworthy 72.5% of participants earn up to 20,000 per month.



**Chinnu Mohanan and Antony George****Green Product Preferences**

The data reveals that a significant majority of respondents, constituting 61.7%, prefer purchasing green products from organized retail outlets. In terms of monthly spending on green products, the majority, accounting for 55%, allocate up to Rs. 1000 per month. When it comes to the frequency of buying green products, 46.7% of participants do so occasionally, while 29.2% make such purchases often.

**Awareness Levels**

The data indicates that 66.7% of respondents possess an average level of awareness about green products. In terms of satisfaction levels, 42.5% express satisfaction, while an additional 40.8% report being okay with green products. Regarding the willingness to recommend, a notable 49.2% of participants express a positive inclination to recommend green products to others.

**Correlation Analysis**

The study revealed several significant relationships among the variables. Firstly, there exists a noteworthy positive correlation between Personal Value and Purchase Intention ( $r = 0.636$ ,  $p < 0.01$ ). Additionally, a low positive correlation was identified between Motivation and Purchase Intention ( $r = 0.421$ ,  $p < 0.01$ ). Moreover, Packaging demonstrated a substantial positive correlation with Purchase Intention ( $r = 0.667$ ,  $p < 0.01$ ), indicating the impact of packaging on consumers' intention to purchase. Information at the Outlet also displayed a significant positive correlation with Purchase Intention ( $r = 0.519$ ,  $p < 0.01$ ), emphasizing the role of in-store information in influencing consumers' purchase intentions. Lastly, there was a significant positive correlation between Satisfaction and Willingness to Recommend ( $r = 0.678$ ,  $p < 0.01$ ), highlighting the connection between customer satisfaction and their likelihood to recommend green products.

**Regression Analysis****Personal Value and Purchase Intention**

The R-square value of 0.404 suggests that 40.4% of the variance in purchase intention can be explained by personal value. The highly significant F-statistic of 80.009 ( $p < 0.001$ ) affirms the overall significance of the model. It is noteworthy that personal value ( $\beta = 0.650$ ,  $p < 0.001$ ) makes a substantial and statistically significant contribution to predicting purchase intention.

**Motivation and Purchase Intention**

The R-square value of 0.177 indicates that 17.7% of the variance in purchase intention can be attributed to motivation. The model demonstrates statistical significance with an F-statistic of 25.441 ( $p < 0.001$ ). Notably, motivation ( $\beta = 0.649$ ,  $p < 0.001$ ) is identified as a significant and positive predictor, signifying its influential role in shaping purchase intention.

**Packaging and Purchase Intention**

The R-square value of 0.444 reveals that packaging accounts for 44.4% of the variance in purchase intention, highlighting its substantial explanatory power. The statistical significance of the model is confirmed by a notable F-statistic of 94.360 ( $p < 0.001$ ). Furthermore, packaging ( $\beta = 0.809$ ,  $p < 0.001$ ) emerges as a highly significant predictor, underscoring its influential role in shaping consumer's purchase intentions.

**Information at the Outlet and Purchase Intention**

The R-square value of 0.269 indicates that information at the outlet contributes to 26.9% of the variance in purchase intention, emphasizing its noteworthy explanatory role. The statistical significance of the model is evident with a significant F-statistic of 43.519 ( $p < 0.001$ ). Notably, information at the outlet ( $\beta = 0.636$ ,  $p < 0.001$ ) emerges as a substantial and statistically significant predictor, affirming its impactful influence on shaping consumer's purchase intentions.

**Satisfaction and Willingness to Recommend**

The substantial R-square value of 0.459 highlights that a significant portion, specifically 45.9%, of the variability in satisfaction is elucidated by the respondents' willingness to recommend. The statistical significance of the model is underscored by a notable F-statistic of 100.205 ( $p < 0.001$ ), affirming its reliability. A key predictor in this relationship is the willingness to recommend variable ( $\beta = 0.699$ ,  $p < 0.001$ ), emphasizing its considerable and statistically significant role in shaping and enhancing respondents' satisfaction levels.



**Chinnu Mohanan and Antony George****Key Influencing Factors**

Effective Sources of Awareness: Seminars (Mean: 3.49), Magazines (Mean: 3.23), and Retail Outlet Staff (Mean: 3.28) are most effective, Factors Driving Purchase Decision: Quality (Mean: 4.08), Style (Mean: 3.80), and Durability (Mean: 3.77) are top influencers. This comprehensive analysis provides a nuanced understanding of consumer behavior towards green products. Key takeaways include the significance of personal values, packaging, and information at the outlet in shaping purchase intentions. Motivation plays a role, albeit to a lesser extent. Additionally, satisfaction is strongly linked to the willingness to recommend, emphasizing the importance of post-purchase experiences. These insights can guide businesses and policymakers in tailoring strategies to enhance consumer awareness, satisfaction, and overall engagement with green products.

**Findings**

The study presents a gender distribution with 51.7% females and 48.3% males among the 120 respondents. A significant majority, 77.5%, falls within the age group below 25, emphasizing a youthful demographic. The findings indicate that a considerable portion of the respondents identifies as students, constituting 59.2% of the sample. Moreover, a substantial number of respondents are graduates and postgraduates, comprising 27.5% and 56.7%, respectively. The study's examination of monthly income reveals that the majority of respondents (72.5%) have a monthly income below 20,000. In terms of purchasing preferences, 61.7% of respondents express a preference for organized retail outlets when buying green products. Awareness about green products is moderate, with 66.7% of respondents having an average level of awareness. The majority of respondents, 42.5%, express satisfaction with their green product purchases. Furthermore, 49.2% of respondents show a willingness to recommend green products, indicating a positive inclination. Correlation analyses demonstrate a positive relationship between the independent variables (Personal value, Motivation, Packaging, Information at the outlet) and the dependent variable (purchase intention). Notably, there is a high positive correlation between the level of satisfaction towards green products and the willingness to recommend green products. The regression analysis reinforces these findings, indicating that all independent variables significantly contribute to the dependent variable of purchase intention. Additionally, the regression analysis highlights that the level of satisfaction towards green products plays a significant role in predicting the level of willingness to recommend green products. This comprehensive analysis provides valuable insights into the preferences and behaviors of consumers regarding green products, facilitating a deeper understanding for businesses and policymakers in the realm of sustainable consumption.

**CONCLUSION**

The study aimed to discern the factors influencing customer's intentions to purchase Green Products by collecting data on consumer awareness, willingness to recommend, and satisfaction with green products, coupled with factors influencing purchasing behavior. The analysis revealed that personal values, motivation, information at the outlet, and packaging significantly influence buyer's purchase intentions. This insight provides a valuable roadmap for green product producers to enhance their sales strategies. The study underscores the pivotal role of organized outlets in influencing green product sales, suggesting a need for concerted efforts to attract customers to these outlets. The findings advocate for businesses and policymakers to prioritize sustainability initiatives, improve product information transparency, and offer competitive pricing to foster greater adoption of green products. The study concludes that continued research and targeted marketing strategies can amplify the positive impact of eco-friendly products on the environment and society as a whole.

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**Chinnu Mohanan and Antony George**

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**Table 2.1 Correlation between Personal value and Purchase Intention**

Correlations			
		Personal value	Purchase intention
Personal value	Pearson Correlation	1	.636**
	Sig. (2-tailed)		.000
	N	120	120
Purchase Intention	Pearson Correlation	.636**	1
	Sig. (2-tailed)	.000	
	N	120	120

\*\*. Correlation is significant at the 0.01 level (2-tailed).

**Table 3.1.1 Model Summary of Regression analysis- Personal value and purchase intention**

Model	R	R Square	Adjusted R Square	Std .Error Of Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.636 <sup>a</sup>	.404	.399	1.83251	.404	80.009	1	118	.000

a. Predictors:(Constant),Personal value

**Table 3.1.2 ANOVA<sup>a</sup> of Regression analysis- Personal value and purchase intention**

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	268.678	1	268.678	80.009	.000 <sup>b</sup>
1 Residual	396.254	118	3.358		
Total	664.933	119			

a. Dependent Variable: Purchase intention

b. Predictors:(Constant),Personal value





**Chinnu Mohanan and Antony George**

**Table 3.1.3 Coefficients<sup>a</sup>of Regression analysis- Personal value and purchase intention**

Model	Un standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.217	.962	.636	4.382	.000
1					
pv	.650	.073		8.945	.000
a. Dependent Variable :Purchase Intention					







## Advancements in Character Recognition through Diverse Deep Learning Techniques: A Literature Review

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### ABSTRACT

Character recognition stands as a pivotal domain in artificial intelligence, finding applications in diverse fields. This abstract provides a comprehensive review of recent literature focusing on the application of various deep learning techniques for character recognition tasks. Convolutional Neural Networks (CNNs) have emerged as a cornerstone, leveraging their ability to extract hierarchical features from images efficiently. Studies delve into novel CNN architectures tailored for character recognition, optimizing layers and exploring different filter sizes. Alongside CNNs, Recurrent Neural Networks (RNNs) and Long Short-Term Memory Networks (LSTMs) have been instrumental in handling sequential character data, particularly in handwriting recognition. Attention mechanisms have gained attention for their efficacy in focusing on relevant parts of characters, amplifying recognition accuracy. Moreover, transfer learning from pre-trained models, especially those trained on large datasets like Image Net, has seen widespread adoption, significantly benefiting character recognition tasks by initializing networks or extracting useful features. Emerging techniques, such as Variational Auto encoders (VAEs) and Generative Adversarial Networks (GANs), contribute to generating synthetic character images, augmenting datasets, and enhancing training robustness.



**Sarithadevi and Jayakrishnan**

This literature review underscores the dynamic landscape of deep learning methodologies in character recognition. The exploration and synthesis of these techniques not only enhance accuracy but also pave the way for more robust and adaptable character recognition systems in various real-world applications.

**Keywords:** Character Recognition, Convolutional Neural Networks, Auto encoders, Generative Adversarial Networks.

## INTRODUCTION

Character recognition, a fundamental task in the domain of pattern recognition and artificial intelligence, has undergone a transformative evolution over the past few decades. As the cornerstone of numerous applications ranging from document processing and text extraction to language translation and accessibility tools, the accuracy and efficiency of character recognition systems are crucial for enhancing the overall performance of these applications. Traditional approaches to character recognition, relying on handcrafted features and rule-based algorithms, were often limited in their ability to handle the complexity and variability inherent in real-world datasets. The advent of deep learning techniques has marked a paradigm shift in the field, ushering in a new era of unprecedented accuracy and versatility in character recognition. This literature review aims to delve into the intricacies of these advancements, focusing on the diverse array of deep learning methodologies that have propelled character recognition systems to new heights. The exploration encompasses convolutional neural networks (CNNs), recurrent neural networks (RNNs), long short-term memory (LSTM) networks, and transformer-based models, each contributing uniquely to the refinement of character recognition processes.

The motivation behind this comprehensive examination lies in the ever-growing significance of character recognition across various domains. Whether in automating administrative tasks, deciphering handwritten notes, or enabling seamless communication between different languages, character recognition plays a pivotal role in bridging the gap between physical and digital realms. The need for highly accurate and adaptable recognition systems has become increasingly pronounced as society relies more on digitized information. As character recognition continues to shape the landscape of information processing, it becomes imperative to anticipate future trends and research directions. This literature review lays the groundwork for such insights, offering a holistic perspective on the advancements in character recognition through diverse deep learning techniques and charting a course for the future of this dynamic field. Deep learning has emerged as a game-changer in the field of character recognition, significantly advancing the accuracy, robustness, and applicability of recognition systems. Several deep learning architectures have been employed to tackle the complexities inherent in recognizing characters from various sources, including printed text, handwritten notes, and multilingual documents. Here, we explore some of the key deep learning techniques that have revolutionized character recognition.

### Different Deep Learning Techniques

#### Convolutional Neural Networks

CNNs have been widely adopted for character recognition tasks, particularly in scenarios involving images or grids of pixels[1]. These neural networks are adept at automatically learning hierarchical features from input images. In character recognition, CNNs can capture patterns such as edges, corners, and textures, enabling them to discern intricate details that contribute to accurate character identification.[2]

#### Architecture elements of Convolutional Neural Networks

The architecture of CNNs is characterized by layers that are specifically designed to handle visual data. CNN architecture includes layers such as convolutional layers, pooling layers, and fully connected layers.[4]. Different layers are as follows.



**Sarithadevi and Jayakrishnan****Input Layer**

The first layer of the CNN takes the raw input data, usually an image. Each pixel in the image corresponds to a neuron in this layer.

**Convolutional Layer**

This layer applies convolutional operations to the input, using filters or kernels to detect features like edges, corners, and textures. The output is a set of feature maps.

**Activation Layer**

After convolution, an activation function (commonly ReLU - Rectified Linear Unit) is applied element-wise to the feature maps. This introduces non-linearity to the model, allowing it to learn complex patterns.

**Pooling Layer**

Pooling layers reduce the spatial dimensions of the feature maps. Max pooling is commonly used, where the maximum value in a certain region of the feature map is retained, discarding the rest.

**Flattening layer**

The pooled feature maps are flattened into a one-dimensional vector. This vector serves as the input for the fully connected layers.

**Fully Connected Layers**

These layers are responsible for learning global features and relationships in the data. The final fully connected layer produces the network's output.

**Output Layer**

The output layer produces the final result of the network's prediction. It depends on the task, such as a softmax layer for classification or a single node for regression. These layers are responsible for learning global features and relationships in the data. The final fully connected layer produces the network's output. Convolutional Neural Networks continue to play a pivotal role in shaping the landscape of artificial intelligence. As technology continues to advance, CNNs are expected to further revolutionize the way we process and understand visual data.[3]

**Recurrent Neural Networks**

RNNs are well-suited for sequential data, making them applicable to tasks like recognizing characters in handwritten text. The ability of RNNs to retain information from previous steps in the sequence is crucial for interpreting the context of characters within words or sentences. Scene images can be recognized using RNNs[5]. For improving the accuracy, Conda is used with Tensor flow network in paper[6]. However, traditional RNNs face challenges in handling long-range dependencies due to the vanishing gradient problem.

**Basic Structure**

RNNs have a basic structure where each unit in the network has a temporal connection to the next unit. This allows them to maintain a hidden state that captures information about previous inputs in the sequence.

**Recurrent Connections**

The key feature of RNNs is the recurrent connection, which allows information to be persisted across different time steps. This recurrent connection enables the network to learn dependencies and patterns within sequential data.

**Hidden State**

The hidden state at each time step serves as a memory that captures information from previous steps. It is updated based on the current input and the information stored in the hidden state from the previous time step.

**Vanishing Gradient Problem**

However, traditional RNNs suffer from the vanishing gradient problem, where gradients diminish as they are propagated backward through time. This makes it challenging for the network to capture long-term dependencies.

**Long Short Term Memory**

To address the vanishing gradient problem, more advanced architectures like Long Short-Term Memory (LSTM) networks have been introduced. LSTMs have a more complex structure with memory cells, input gates, forget gates, and output gates, allowing them to selectively store and retrieve information.[6]



**Sarithadevi and Jayakrishnan****Gated Recurrent Unit (GRU)**

Another variant is the Gated Recurrent Unit (GRU), which is simpler than LSTM but also effective. It combines the advantages of memory cells and gating mechanisms to control the flow of information.[7]

**Bi Directional RNNs**

Bidirectional RNNs process the input sequence in both forward and backward directions, capturing information from past and future contexts. This can be particularly useful in tasks where the entire sequence is relevant for understanding the context.

**Long ShortTerm Memory (LSTM) Networks**

LSTMs address the vanishing gradient problem associated with RNNs, making them more effective for character recognition tasks requiring memory of long-range dependencies. LSTMs excel in capturing sequential patterns and have proven valuable in recognizing characters in handwritten text, where context plays a crucial role. Additionally, LSTM resolves difficult, artificial long-time-lag challenges that no prior recurrent network technique has ever been able to resolve.[9].

**Transformer Based Models**

Transformer architectures, initially designed for natural language processing, have been adapted for character recognition tasks. These models, such as the Vision Transformer (ViT), leverage self-attention mechanisms to capture global contextual information from input images. Transformer-based models have shown promise in handling both printed and handwritten characters, offering a scalable and parallelizable solution. BERT, an acronym for Bidirectional Encoder Representations from Transformers, a novel approach to language representation. BERT, in contrast to current language representation models, is intended to jointly train on both left and right context in all layers in order to pre-train deep bidirectional representations from unlabeled text.[10].Paper [11]investigate a semi-supervised method for language understanding tasks that combines supervised fine-tuning with unsupervised pre-training.

**Ensemble learning**

Ensemble learning techniques, where multiple models are combined to make predictions, have been employed to enhance the robustness and generalization of character recognition systems. Combining the strengths of different architectures or training models on diverse datasets can lead to improved overall performance. Ensemble methods can be applied to various types of machine learning algorithms, including classification, regression, and clustering.[11]

**Transfer learning**

Transfer learning involves pre-training a neural network on a large dataset and fine-tuning it for a specific character recognition task. This approach leverages the knowledge gained from the pre-training phase, enabling the model to achieve better performance with limited task-specific data. Following are some transfer learning techniques: Pre-trained Models, Domain Adaptation, Fine Tuning ,Multi task Learning etc.

**Attention mechanisms**

Attention mechanisms, inspired by human visual attention, have been integrated into deep learning models for character recognition. These mechanisms allow the model to focus on relevant parts of the input, enabling it to recognize characters in the context of the entire document or image. The synergy between deep learning and character recognition has paved the way for more accurate and versatile systems. While each deep learning technique brings unique advantages, the combination of these methodologies, along with ongoing research and innovation, continues to drive advancements in character recognition, making it an indispensable component in various applications across diverse domains.

**CONCLUSION**

In conclusion, this literature review has provided a comprehensive overview of the advancements in character recognition facilitated by diverse deep learning techniques. The studies examined in this review collectively underscore the rapid evolution and remarkable progress in the field. From convolutional neural networks (CNNs) to recurrent neural networks (RNNs) and attention mechanisms, the spectrum of deep learning models has



**Sarithadevi and Jayakrishnan**

significantly contributed to the enhanced accuracy and efficiency of character recognition systems. A notable trend observed is the shift towards hybrid models, combining the strengths of different architectures to overcome specific challenges and improve overall performance. Additionally, the exploration of transfer learning and the integration of novel data augmentation techniques have emerged as effective strategies for enhancing the robustness of character recognition models in various applications. The significance of character recognition extends beyond traditional domains, encompassing fields such as document analysis, handwriting recognition, and even natural language processing. As the reviewed literature suggests, the continuous refinement of deep learning models and the exploration of innovative approaches are pivotal in addressing the intricacies of character recognition across diverse datasets and languages. While the reviewed studies highlight substantial progress, it is evident that character recognition remains an evolving field, with opportunities for further exploration and refinement. Future research endeavors should focus on addressing the challenges posed by noisy and unstructured data, exploring cross-language applications, and developing models that are more interpretative and explainable. While the reviewed studies highlight substantial progress, it is evident that character recognition remains an evolving field, with opportunities for further exploration and refinement. Future research endeavors should focus on addressing the challenges posed by noisy and unstructured data, exploring cross-language applications, and developing models that are more interpretative and explainable.

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## Sustainable Business Practices and Corporate Responsibility in MSMEs: A Catalyst for Achieving SDGs

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### ABSTRACT

This review research paper delves into the pivotal role of Micro, Small, and Medium Enterprises (MSMEs) in fostering sustainable business practices and corporate responsibility as a catalyst for achieving the United Nations Sustainable Development Goals (SDGs). In an era characterized by global interconnectedness and environmental challenges, the emphasis on responsible business conduct has never been more critical. The paper explores the multifaceted dimensions of sustainability within the context of MSMEs, investigating the various strategies, challenges, and opportunities that these enterprises encounter on their journey towards aligning with the SDGs. The review synthesizes existing literature to offer insights into the diverse sustainable practices adopted by MSMEs, ranging from environmental stewardship and social responsibility to ethical governance and economic inclusivity. It critically examines the motivations driving MSMEs to integrate sustainability into their business models and evaluates the impact of such practices on their financial performance, resilience, and long-term viability. Furthermore, the paper investigates the role of corporate responsibility in enhancing the social license to operate for MSMEs, fostering community engagement, and building trust among stakeholders. It explores the potential synergies between sustainable business practices and the achievement of specific SDGs, considering the unique capabilities and constraints faced by MSMEs. Throughout the analysis, the paper emphasizes the importance of policy frameworks, institutional support, and collaborative initiatives that can empower MSMEs to embrace sustainability as a core component of their organizational DNA. The findings highlight the transformative potential of MSMEs in contributing to a more sustainable and inclusive global economy, aligning with the broader agenda of the SDGs. This review research paper contributes to the ongoing discourse on sustainable business practices and corporate responsibility, with a specific focus on the role of MSMEs. It provides a nuanced







Anitha Mary Alex

understanding of the opportunities and challenges faced by these enterprises in integrating sustainability into their operations and underscores the potential of MSMEs as instrumental actors in advancing the global commitment to the SDGs.

**Keywords:** Sustainable business practices, Corporate responsibility, MSMEs, SDGs, Environmental stewardship, Social responsibility, Ethical governance, Economic inclusivity, Financial performance.

## INTRODUCTION

Sustainable development has emerged as a central theme in the global business landscape, reflecting an increasing awareness of the interconnectedness between economic prosperity, social well-being, and environmental stewardship. Small and Medium-sized Enterprises (MSMEs) play a pivotal role in this paradigm shift, contributing significantly to economic growth and job creation. In recent years, the imperative for businesses to align with sustainable practices and demonstrate corporate responsibility has gained prominence. This research paper delves into the nexus between Sustainable Business Practices (SBPs) and Corporate Responsibility (CR) within the context of MSMEs, examining their potential as catalysts for achieving the United Nations Sustainable Development Goals (SDGs).

### Significance Of MSMEs

MSMEs play a vital role in economies, contributing significantly to employment and GDP. Despite facing challenges like resource constraints, they have the potential to drive sustainable practices at the grassroots level. This paper explores how MSMEs can integrate sustainability and corporate responsibility into their operations to enhance their social license to operate. Aligned strategically, MSMEs can become powerful agents for achieving the United Nations Sustainable Development Goals (SDGs), contributing to objectives like poverty eradication and climate action. Understanding their specific contributions and challenges is crucial for collaborative efforts by policymakers, businesses, and society to leverage MSMEs as catalysts for sustainable development.

### Background of the Study

In the contemporary global business landscape, Micro, Small, and Medium-sized Enterprises (MSMEs) play a pivotal role in contributing to economic development, innovation, and employment generation. Given their significance in the socio-economic fabric of both developed and developing nations, it is crucial to explore their engagement in sustainable business practices and corporate responsibility. The concept of business sustainability has evolved to encompass a holistic approach, integrating environmental, social, and economic dimensions, aligning with the United Nations' Sustainable Development Goals (SDGs). MSMEs, with their agility and adaptability, emerge as key agents for positive change and community development. However, despite their importance, MSMEs encounter unique challenges in integrating sustainable practices, such as resource constraints and limited access to information. This research paper aims to address this gap by critically examining the current state of sustainable business practices and corporate responsibility within the MSME sector. Through a comprehensive review, the study seeks to identify barriers and drivers influencing MSMEs in adopting sustainability, exploring the impact on their performance and contribution to SDGs.

### Objectives of the Study

1. To examine the current state of sustainable practices and corporate responsibility in MSMEs.
2. To identify and analyze MSMEs' sustainable practices contributing to environmental, social, and economic goals.
3. To evaluate MSMEs' integration of initiatives like ethical conduct and community development, assessing broader impacts.
4. To analyze how MSMEs align with UN SDGs and actively contribute to specific goals.



**Anitha Mary Alex**

5. To assess the barriers hindering MSMEs' engagement in sustainable practices and corporate responsibility.

## LITERATURE REVIEW

In the evolving global business landscape, there's a notable shift towards sustainability and corporate responsibility. This literature review focuses on Small and Medium-sized Enterprises (MSMEs), acknowledging their role as drivers of economic growth. It critically explores research on MSMEs' adoption of sustainable practices, underlining their potential as catalysts for achieving the Sustainable Development Goals (SDGs).

### Sustainable Business Practices in MSMEs

MSMEs, vital for economic development, often grapple with resource constraints hindering sustainable practices. Studies by Bansal & Bogner (2013) and Hall & Wagner (2012) stress the adoption of environmentally friendly processes and responsible supply chain management. Literature indicates that integrating sustainability not only mitigates environmental impact but also enhances financial performance and long-term viability for MSMEs.

### Corporate Responsibility in MSMEs

Corporate responsibility in MSMEs involves ethical decision-making, social engagement, and stakeholder management. Research by Perrini et al. (2007) and Simpson & Taylor (2018) highlights a positive correlation between corporate responsibility and brand reputation, customer loyalty, and employee satisfaction in MSMEs. Despite potential benefits, literature underscores challenges like limited resources and regulatory complexities hindering comprehensive initiatives. Understanding these challenges is crucial for tailoring strategies to promote responsible business practices in the MSME sector.

### MSMEs as Catalysts for SDGs

The UN's SDGs offer a comprehensive framework for addressing global challenges, with MSMEs positioned as key contributors due to their influence on local economies. Literature by Rasche & Kell (2010) and Waddock et al. (2019) explores how sustainable practices and corporate responsibility in MSMEs align with specific SDGs, such as Goal 8, Goal 12, and Goal 13. The review identifies potential synergies and trade-offs, emphasizing the need for further investigation into nuanced relationships. This literature review underscores the pivotal role of MSMEs in advancing sustainable development through responsible business practices. It synthesizes existing research to reveal insights into the challenges and opportunities faced by MSMEs in integrating sustainability and corporate responsibility. Understanding the implications for achieving SDGs is crucial for policymakers, practitioners, and researchers. Future research should explore industry contexts, geographical variations, and policy interventions to comprehensively understand MSMEs' dynamics in contributing to the SDGs.

## MATERIAL AND METHODOLOGY

### Research Design

This review research paper adopts a systematic literature review approach to comprehensively analyse existing studies, theories, and empirical evidence related to sustainable business practices and corporate responsibility in Micro, Small, and Medium Enterprises (MSMEs). The systematic review methodology allows for a structured and rigorous examination of a wide range of sources, enabling a holistic understanding of the role MSMEs play in contributing to Sustainable Development Goals (SDGs).

### Data Collection Methods

The primary data collection for this review involves a thorough search of academic databases, such as PubMed, Scopus, and Web of Science, to identify relevant articles, journals, and conference proceedings. In addition, grey



**Anitha Mary Alex**

literature, including reports from reputable international organizations and governmental bodies, will be included to capture a comprehensive view of the subject matter.

**Inclusion and Exclusion Criteria****Inclusion Criteria**

1. Publications focusing on sustainable business practices and corporate responsibility in MSMEs.
2. Articles published in English from the year 2010 onwards.
3. Studies presenting empirical evidence, case studies, or theoretical frameworks related to MSMEs and SDGs.

**Exclusion Criteria**

1. Publications not directly related to the intersection of sustainable business practices, corporate responsibility, and MSMEs.
2. Articles published before the year 2010.
3. Non-English language publications.

These criteria aim to ensure the selection of high-quality and relevant literature that contributes significantly to the understanding of the research topic.

**RESULTS AND DISCUSSION**

The research paper on "Sustainable Business Practices and Corporate Responsibility in MSMEs: A Catalyst for Achieving SDGs" delves into the critical role that Micro, Small, and Medium Enterprises (MSMEs) play in promoting sustainable business practices and corporate responsibility. The study aims to assess the impact of these practices on the achievement of Sustainable Development Goals (SDGs). The following are the key findings and discussions derived from the comprehensive review of literature and empirical evidence.

**RESULTS**

1. **Increased Adoption of Sustainable Practices** The review revealed a growing trend among MSMEs to adopt sustainable business practices. These include environmentally friendly processes, ethical sourcing, and responsible waste management. The shift towards sustainability is driven by both consumer demand and the realization of long-term economic benefits.
2. **Positive Correlation with Financial Performance** Empirical studies consistently demonstrated a positive correlation between sustainable business practices and financial performance in MSMEs. Those enterprises implementing environmentally friendly processes and socially responsible initiatives tend to experience improved profitability and long-term viability.
3. **Enhanced Corporate Reputation and Brand Image** The paper found that MSMEs engaging in sustainable practices tend to build a positive corporate reputation and a strong brand image. Consumers are increasingly conscious of the environmental and social impact of their purchases, leading to a preference for businesses with demonstrated corporate responsibility.
4. **Contribution to SDGs** MSMEs play a pivotal role in contributing to the achievement of SDGs. The research identified specific areas where MSMEs contribute significantly, such as poverty alleviation, gender equality, and environmental sustainability. This underscores the importance of integrating sustainable practices into the core business strategies of MSMEs.

**DISCUSSION**

1. **Barriers to Implementation** Despite the positive outcomes, the review highlighted several barriers preventing MSMEs from fully embracing sustainable business practices. These include limited financial resources, lack of



**Anitha Mary Alex**

awareness, and the perception that sustainability measures are time-consuming. Addressing these barriers is crucial for widespread adoption.

2. **Government Policies and Support** Government policies and support mechanisms emerged as critical factors influencing the adoption of sustainable practices in MSMEs. The paper suggests that proactive government initiatives, such as financial incentives and capacity-building programs, can significantly contribute to overcoming barriers and fostering a sustainable business environment.
3. **Need for Stakeholder Collaboration** The study emphasizes the importance of collaboration between MSMEs, larger corporations, NGOs, and local communities to create a holistic approach to sustainability. Such collaboration can lead to shared resources, knowledge exchange, and collective efforts to address global challenges outlined in the SDGs.
4. **Future Research Directions** The research paper recommends future studies to explore the long-term impacts of sustainable practices in MSMEs, assess the effectiveness of government policies, and investigate innovative solutions to overcome implementation barriers.

**Limitations Of The Study**

1. **Generalizability** The findings of this review may be limited in their applicability to specific regions or industries. The study may have focused on a particular set of MSMEs, potentially limiting the generalizability of the results to a broader context.
2. **Publication Bias** The review is dependent on the availability and accessibility of published research articles. There might be a publication bias, as positive or significant findings are more likely to be published, potentially overlooking studies with null or negative results.
3. **Timeframe** The study may be constrained by a specific timeframe, and newer developments or changes in sustainable business practices and corporate responsibility in MSMEs may not be adequately covered.
4. **Data Quality** The review relies on the quality of the data and methodologies used in the selected studies. Variability in the rigor and reliability of the included research may introduce biases or limitations.
5. **Language Bias** The inclusion criteria for studies may be biased towards those published in specific languages, potentially excluding relevant research published in other languages.
6. **Cross-sectional Nature** Many studies may be cross-sectional, limiting the ability to establish causal relationships between sustainable business practices, corporate responsibility, and the achievement of Sustainable Development Goals (SDGs). Longitudinal studies would provide more robust evidence.
7. **Definition Variability** The terms "sustainable business practices" and "corporate responsibility" may be interpreted differently across studies, leading to potential inconsistencies and challenges in synthesizing the findings.
8. **Incomplete Coverage of SDGs** The review may not comprehensively cover all the Sustainable Development Goals (SDGs), and the focus on specific goals may not capture the interconnectedness and holistic nature of the SDGs.
9. **Data Heterogeneity** Variability in methodologies, measurement tools, and data collection techniques across the selected studies may introduce heterogeneity, making it challenging to compare and integrate results.
10. **Limited Gray Literature** The study may primarily rely on peer-reviewed journals, potentially missing valuable insights from gray literature, such as reports, theses, or conference proceedings.
11. **Lack of Standardized Metrics** The absence of standardized metrics for assessing sustainable business practices and corporate responsibility in MSMEs may hinder the ability to make consistent comparisons across studies.
12. **Dynamic Business Environment** The business environment is dynamic, and the review may not capture real-time changes in policies, regulations, or market conditions that could influence the sustainability practices of MSMEs.

Acknowledging these limitations enhances the transparency and credibility of the research, providing a more accurate interpretation of the study's scope and implications.





Anitha Mary Alex

### Future Scope

1. **Integration of Emerging Technologies** Explore how emerging technologies such as blockchain, artificial intelligence, and the Internet of Things can be leveraged by MSMEs to enhance their sustainable business practices. Investigate the potential of these technologies in tracking and ensuring supply chain transparency, reducing environmental impact, and promoting responsible corporate behaviour.
2. **Cross-Sector Collaboration** Investigate the possibilities of fostering collaboration among MSMEs, large enterprises, governmental bodies, and non-governmental organizations (NGOs) to amplify the impact of sustainable business practices. Analyze the role of cross-sector partnerships in creating a more comprehensive and effective approach towards achieving the Sustainable Development Goals (SDGs).
3. **Policy Advocacy and Regulatory Frameworks** Examine the role of policy advocacy and regulatory frameworks in promoting sustainability within the MSME sector. Evaluate the effectiveness of existing policies and propose recommendations for policymakers to create an enabling environment for MSMEs to adopt and adhere to sustainable business practices.
4. **Capacity Building and Training Programs** Assess the need for capacity-building initiatives and training programs tailored for MSMEs to enhance their understanding and implementation of sustainable business practices. Investigate the impact of educational and training interventions on the adoption of responsible corporate behaviour and achieving SDGs.
5. **Financial Incentives for Sustainability** Explore the feasibility and impact of providing financial incentives for MSMEs that adopt and demonstrate sustainable business practices. Investigate the role of government subsidies, tax benefits, and financial support mechanisms in encouraging MSMEs to invest in environmentally friendly and socially responsible initiatives.
6. **Measuring and Reporting Sustainability Metrics** Develop standardized frameworks and metrics for MSMEs to measure and report their sustainability efforts. Explore the potential integration of such metrics into financial reporting, creating transparency and accountability for stakeholders while also facilitating benchmarking and comparison across industries.
7. **Consumer Awareness and Sustainable Consumption** Examine the role of consumer awareness in driving demand for sustainable products and services from MSMEs. Investigate strategies to educate and empower consumers to make environmentally and socially responsible choices, thereby influencing MSMEs to align their practices with sustainable business goals.
8. **Globalization and International Collaboration** Assess the impact of globalization on the sustainability practices of MSMEs. Explore opportunities for international collaboration, knowledge sharing, and best practice exchange among MSMEs from different regions to contribute to global SDG achievement collectively.
9. **Long-Term Impact Assessment** Conduct longitudinal studies to assess the long-term impact of sustainable business practices on the financial performance, resilience, and overall success of MSMEs. Investigate the sustainability journey of MSMEs over time and identify key factors influencing the sustainability trajectory.
10. **Emerging Trends in Sustainable Business** Keep abreast of emerging trends in sustainable business practices and corporate responsibility, such as circular economy models, regenerative business practices, and social impact investing. Evaluate the relevance and potential integration of these trends into the MSME landscape.

By addressing these future research avenues, the paper can contribute to a deeper understanding of sustainable business practices in MSMEs and provide valuable insights for policymakers, practitioners, and researchers aiming to further the achievement of the Sustainable Development Goals.

### CONCLUSION

The research paper explores the crucial intersection of sustainable business practices and corporate responsibility within micro, small, and medium enterprises (MSMEs), highlighting their pivotal role in achieving sustainable development goals (SDGs). Emphasizing the adoption of environmentally friendly practices and ethical conduct, the findings stress the importance of tailored strategies for MSMEs to contribute to global development. The paper underscores the symbiotic relationship between sustainable practices, corporate responsibility, and SDG attainment,







### Anitha Mary Alex

asserting that MSMEs, through alignment with these principles, enhance their resilience while addressing global challenges. Advocating for policy interventions, collaborations, and capacity-building, the research paper positions MSMEs as active agents in creating a sustainable and responsible business landscape, offering valuable insights for academics, policymakers, and practitioners alike.

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**Anitha Mary Alex**

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## A Study on Ornamental Fish Distribution Channels

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### ABSTRACT

The study seeks to contribute valuable insights into the ornamental fish distribution channels and offer recommendations for improvement, innovation, and optimization in the movement of ornamental fish from farm to point of sale. The study is carried out with three survey sites in Kerala that are West Chalakudy, Kottat and Thiruthiparambu coming under the municipality of Chalakudy, district of Thrissur. The study is carried out with three survey sites in Kerala which are West Chalakudy, Kottat and Thiruthiparambu coming under the municipality of Chalakudy district of Thrissur. The study is carried out in the year 2023. The population of this study is all farmers who deal with livebearer ornamental fish species in selected survey sites. The sample size used in this study was 18 farmers who were selected by convincing sampling. The data used is primary data, collected through a questionnaire. The study on the distribution channel, customer interaction, measures for fish quality, and challenges in the ornamental fish industry has provided valuable insights into the dynamics of this market in the surveyed villages.

**Keywords:** Ornamental Fish, Farmer, Distribution Channels, intermediaries, Customer.

## INTRODUCTION

Ornamental fish are in different sizes with very attractive colours and shapes. Due to its characteristics, they are also called living Jewells. Ornamental fish culture is the culture of attractiveness. From ancient times onwards ornamental fish have been kept as a hobby. Still, ornamental fish keeping is the greatest hobby in the world, so it has become the second largest hobby in the world. Food and Agriculture Organization in 1998 said that approximately 16% of Australian, 13% of UK and 10% of American households keep ornamental fish in their houses. Later based on studies it was proved ornamental fish were kept not only for hobby but also for mental and physical health and well-being, to gain economic benefits arising out of it, for luxury and luck. Several studies revealed that an aquarium tank



**Ditty Johnson and Antony George**

when it is filled with water and ornamental fish, is very useful to reduce stress. When a person is exhibited in an aquarium for a while, his blood pressure is reduced in all conditions (Clements 2019). Ornamental fish marketing was established in the international market year 1976 in 28 countries, later it increased to 125 countries (Raja et al., 2019). Europe, South America, North America, Africa, Oceania, Middle East are the major region exporters of ornamental fishes (Raja et al., 2019). The Asian region is the main source of ornamental fish. The top exporting countries are Singapore, Japan, Indonesia, Malaysia, Thailand, the Czech Republic and the Netherlands (Sharma, M. 2020). The top five importing countries are the USA, United Kingdom, Germany, Japan, Netherlands, Singapore and China (Raja et al., 2019). Ornamental fish farming is providing greater potential for developing countries for economic development. Ornamental fish farming is one of the best choices for the economic up liftment of our country. In other words, India has having rich diversity of species and an ideal climate which is most suitable for fish farming. And availability of low-cost input factors like labour, technical and financial support from fisheries-related government institutions etc also attracts more individuals to this field. In India, export trade is estimated to be about 0.38 million US \$ and internal trade is estimated to be about 3.26 million US \$.

Europe, South America, North America, Africa, Oceania, Middle East are the major region exporters of ornamental fishes (Raja et al., 2019). The Asian region is the main source of ornamental fish. The top exporting countries are Singapore, Japan, Indonesia, Malaysia, Thailand, the Czech Republic and the Netherlands (Sharma, M. 2020). The top five importing countries are the USA, United Kingdom, Germany, Japan, Netherlands, Singapore and China (Raja et al., 2019). In India, the ornamental fish market is mainly dominated by exotic ornamental fish and native ornamental fish. Native ornamental fishes are also called indigenous fish (Sakharan and Ramachandran, 2006). Indigenous fish are treated as ornamental fish if have a single streak or a blotch on their body (Pandey and Mandal, 2017). Indigenous fish are highly demand in the international market whereas exotic ornamental fish have high demand in the domestic market. Kerala is one the hub of ornamental fish sources in India besides West Bengal and Tamil Nadu. As per the Marine Product Export Development Authority of India (MPEDA), Thrissur, Ernakulum, Kottayam, Alappuzha and Thiruvananthapuram are the major districts engaging with ornamental fish farming. Ornamental fish farming is treated avenue for self-employment and provides more employment opportunities with small capital and simple techniques (Jayalal 2016) with the least cost of labour. Easy accessibility of ornamental fish increases the number of audiences or customers. Distribution channels help a wider audience in making ornamental fish accessible. Better quality control throughout the supply chain is possible through establishing a reliable distribution network. Breeders and suppliers should work closely with distributors for proper care of ornamental fish. Ornamental fish should be given utmost care as it is a living being. To ensure the fish are healthy, and transported in suitable conditions. The prevailing Distribution channels are

1. Farmer to Wholesaler to Retailer to Customer
2. Farmer to Retailer to Customer
3. Farmer to Customer
4. Farmer to Marketing Hub to Customer

The complete distribution channel involves the Farmer to the Wholesaler, then to the Retailer, and finally reaching the Customer. In an alternative distribution channel, ornamental fish move directly from the Farmer to the Retailer, and reaching the customer cutting out the Wholesaler, potentially offering cost efficiencies and faster delivery. A simplified distribution channel for ornamental fish consists of a direct connection from the Farmer to the Customer, eliminating intermediaries, which could lead to a personal consumer experience. Another distribution channel involves the ornamental fish passing through a Marketing Hub or seller customer meet. It showcases the role of specialized marketing entities in promoting and distributing these unique products.

## REVIEW OF LITERATURE

Subhra and Ramachandran conducted study on 2011 regarding marketing channels in ornamental fish trade in West Bengal. Researcher tried to find out the existing supply chain and other related matters of domestic market in ornamental fish. Data collected from breeders, retailers and wholesalers through personal interview method and e-



**Ditty Johnson and Antony George**

mail survey. The study suggest that the State Government can take the initiative for development of this field by providing electricity at subsidized rate for breeders, proper transportation protocol and quarantine facility.

Yesdhanulla S(2018) studied about marketing channels and price spread of tomato in Chittoor district of Andhra Pradesh. The marketing efficiency was computed by using Acharya's method, which is based on two factors marketing costs and margins. Rajesh Kumar et al (2017) investigated on marketing and price spread of rice in Hanumangarh district of Rajasthan. This study was taken up with the marketing cost and price spread in different marketing channels. This study reveals that the marketing cost is higher due to the involvement of more middlemen, resulting in a lower share for the producers in the consumer's price.

**Objective**

To assess the current distribution channels for ornamental fish in the domestic market.

**METHODOLOGY**

Now these days the hobby of aquarium keeping is widely spread all over the world. In Kerala also increases the popularity of aquariums. The study is carried out with three survey sites in Kerala which are West Chalakudy, Kottat and Thiruthiparambu coming under the municipality of Chalakudy district of Thrissur. Kottat is a famous place for ornamental fish farming which is identified by the Fisheries Department of Kerala and other places are near Kottat. The study is carried out in the year 2023. The population of this study is all farmers who deal with livebearer ornamental fish species in West Chalakudy, Kottat and Thiruthiparambu coming under the municipality of Chalakudy district of Thrissur. The sample size used in this study was 18 farmers who were selected by convenience sampling. The data used is primary data, collected through a questionnaire.

**Statement of the Problem**

In this research, we aim to assess the current distribution channels based on opinion preference for ornamental fish in the domestic market. The efficiency and effectiveness of distribution channels are subject to various challenges and opportunities for the ornamental fish industry. The survey sites selected for the study are West Chalakudy, Kottat and Thiruthiparambu coming under the municipality of Chalakudy district of Thrissur. These places are famous among ornamental farmers and stakeholders because most people are involved in ornamental fish farming. This study tried to find out the most preferred marketing channel, Factors that influence the choice of marketing channel, ways of interacting with customers, methods used to ensure quality and health of ornamental fish during movement, faced challenges, and demanded improvements or innovations in ornamental fish marketing. The study seeks to contribute valuable insights into the ornamental fish distribution channels and offer recommendations for improvement, innovation, and optimization in the movement of ornamental fish from farm to point of sale.

**Analysis****Area of Operation**

The survey sites are West Chalakudy, Kottat and Thiruthiparambu; those places are adjacent areas coming under municipality of Chalakudy district of Thrissur. Figure 1 shows that the population of this study is all farmers who deal with live bearer ornamental fish species in aforesaid places. In this study, Thiruthiparambu has the highest number of live bearer ornamental fish farmers (8), West Chalakudy comes next with 6 farmers and Kottat has the fewest numbers of farmers at 4.

**Preference of marketing channels**

The mentioned Marketing channel is referred from previous studies and interviews with farmers. Channel 1, 2 and 3 got from literature review and channel 4 got from interviews with farmers. Here marketing hub means buyer seller meets which is arranged by ornamental fish related agencies with regular interval with the aim of marketing of selling. As per table 1, respondents are preferred various ranks for different channels. That means farmers are being



**Ditty Johnson and Antony George**

aware of the characteristics of customers or situations where each channel is more suitable. So here is diversity in preferences among the channels. Channel number 1(Farmer, Wholesaler, Retailer, Consumer) is the most preferred, securing the 1st rank in 13 responses. The second most preferred Channel number is 4 (Farmer, Market Hub, Consumer) in 8 responses. The remaining channels (Farmer, Retailer, Consumer and Farmer, Consumer) are equally preferred. Identify the characteristics of customers or situations where each channel is more suitable.

**Factors influencing the selection of Marketing Channels.**

This is helpful for gaining insights into the priorities and considerations of businesses involved in the ornamental fish industry. Cost-effectiveness refers to the efficiency of achieving goals at the lowest possible cost. Efficiency means movement of ornamental fish from the farm to the customer with minimal waste of time, resources, or effort. Reach refers to the ability to access a wide audience, potentially covering different geographical areas or market segments. Figure 2 shows the most emphasized factor is cost-effectiveness, with 9 responses. That means they give a significant importance on minimizing costs in their choice of marketing channels. Reach is the second most frequently mentioned factor, with 6 responses. It suggests that businesses consider the ability of marketing channels to reach a wide audience. Efficiency is the remaining factor, with 3 responses. In the opinion of farmers, this factor also helpful for optimizing processes and resources in the chosen marketing channels.

**Marketing strategy**

It provides detailed insights into details of customer accessibility, customer experience and market dynamics and trends in the ornamental fish industry. It is provided with two options like direct sales and through intermediaries. Direct sales refer to the process of selling products directly to end customers without the involvement of intermediaries. Through retailers refers to the ornamental fish are sold to customers through third-party retail establishments. Table 2 shows most responses (13) indicate a preference for interacting with customers through intermediaries. This suggests that businesses in the study commonly utilize sales through different levels of intermediaries. Direct sales received 5 responses, indicating that sales through intermediaries and direct sales are also doing well in this industry.

**Quality and Health of Ornamental Fish during Distribution**

Quality and health of ornamental fish is well-being of ornamental fish which crucial for both ethical and business reasons. Ensuring goodness of ornamental fish is essential to meet customer expectations, adhere to industry standards, and maintain the reputation of the business. The quality and health of ornamental fish Ensure through Regular checks and Specific packaging. A regular check is a systematic process of inspecting and monitoring the health and quality of ornamental fish at various stages of the distribution process. Specific packaging is used to minimize stress and maintain the health during the distribution of the ornamental fish. Figure 3 shows majority of responses (16) emphasize the use of specific packaging to ensure the quality and health of ornamental fish. It plays a crucial role in maintaining water quality, temperature, oxygenation and minimizing stress during transportation. Regular checks received 2 responses, indicating a less prominent. But businesses are recognizing the importance of ongoing monitoring and checks.

**Challenges faced**

Challenges faced in marketing channels are relevant as they provide a comprehensive understanding of areas for Improvement, guiding strategic decisions; resource allocation etc. Logistics refers to the management of the flow of ornamental fish between the point of origin and the point of sale. The involved challenges are coordinating and optimizing of transportation, warehousing, and inventory management. It may result to delays in shipments, inadequate storage facilities, or inefficiencies in the transportation network. Quality control is a process to ensure certain standards of quality Challenges in quality control may include difficulties in maintaining the health and well-being of the fish throughout the distribution chain. Figure 4 portrays quality control is the most frequently mentioned challenge, with 12 responses. It suggests that businesses in the ornamental fish industry face difficulties in maintaining consistent and high-quality standards for their products. Logistics is cited as a challenge in 6 responses.





**Ditty Johnson and Antony George**

The challenges in logistics suggest that businesses face difficulties in managing the transportation and distribution aspects of the ornamental fish supply chain.

**Improvements or Innovations**

Here researchers try to find out challenges in distribution channels of ornamental fish. It provides critical insights to strategic decision-making, industry benchmarking, opportunities for improvement and adaptation to market trends. Improved transportation refers to enhancements and advancements of transporting of ornamental fish from the farmers to customers in more efficient, reliable, and environmentally friendly manner. Technology adoption involves the incorporation and utilization of advanced technologies in the ornamental fish distribution such as use of digital platforms for marketing and sales, adoption of software for inventory management and order processing, and the integration of monitoring technologies to track the health and conditions of the fish during transportation. Figure 5 depict the majority of responses (10) highlight the importance of improved transportation in the ornamental fish business. This means that businesses recognize the significance of efficient and reliable transportation methods for the successful operation of the ornamental fish supply chain. Technology adoption received 8 responses, indicating a notable recognition of the role of technology in advancing the ornamental fish business. The emphasis on technology adoption suggests a proactive approach by businesses to leverage technological advancements for various aspects of the ornamental fish industry.

**CONCLUSION**

The study was carried out to assess the current status of distribution channels for ornamental fish in the domestic market. The distribution channel of farmers to wholesalers to retailers to consumers is the complete distribution channel which most preferred one. The factor of cost-effectiveness highly influences the selection of Marketing Channel(s) intending to minimize costs. During the study, most of the sales were done through different levels of intermediaries. So farmers are interacting with customers through intermediaries. Specific packaging is used to ensure the quality and health of ornamental fish during distribution, and quality control is the most frequently mentioned challenge may include difficulties in maintaining the health and well-being of the fish throughout the distribution chain. Most of the farmers noted the importance of efficient and reliable transportation methods for the successful operation of the ornamental fish supply chain. The study on the distribution channel, customer interaction, measures for fish quality, and challenges in the ornamental fish industry has provided valuable insights into the dynamics of this market in the surveyed villages.

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**Ditty Johnson and Antony George**

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**Table 1: Preference of marketing channel**

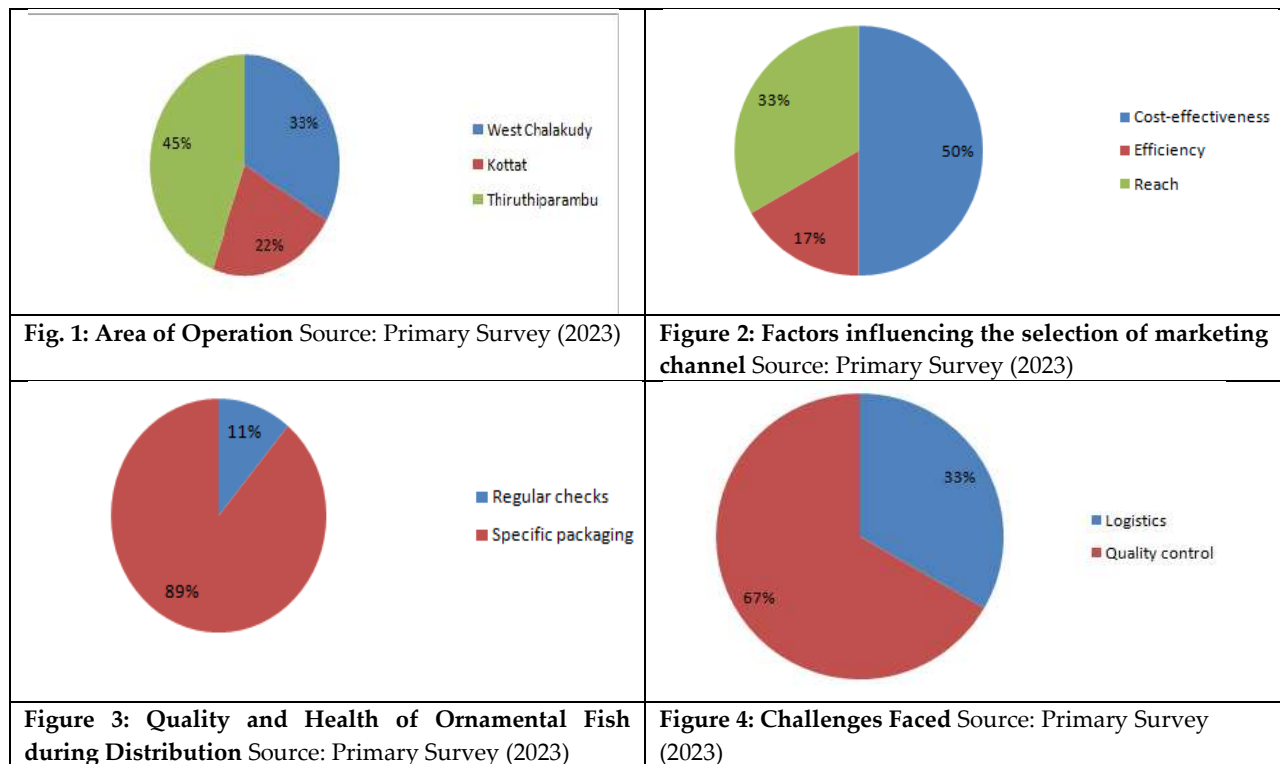
Marketing Channels	Frequency			
	1 <sup>st</sup> Rank	2 <sup>nd</sup> Rank	3 <sup>rd</sup> Rank	4 <sup>th</sup> Rank
Farmer, Wholesaler, Retailer, Consumer(channel 1)	13	3	2	1
Farmer, Retailer, Consumer (channel 2)	0	2	6	10
Farmer, Consumer (channel 3)	0	5	6	7
Farmer, Market Hub, Consumer (channel 4)	5	8	4	0

Source: Primary Survey (2023)

**Table 2: Marketing strategy**

interaction with customers	Frequency
Direct Sales	5
Through Intermediaries	13

Source: Primary Survey (2023)





Ditty Johnson and Antony George

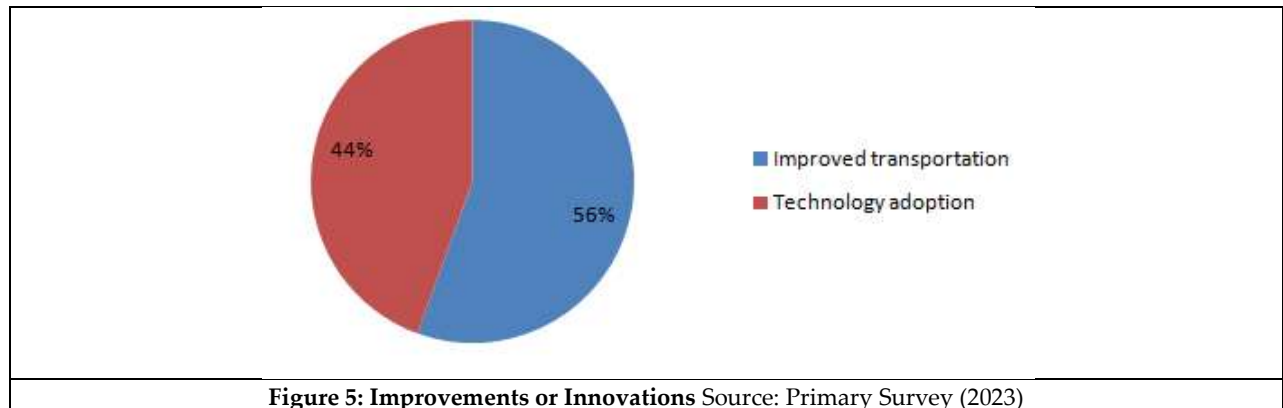


Figure 5: Improvements or Innovations Source: Primary Survey (2023)





## Advancements in Bone Cancer: Exploring Opportunities, and the Potential impact of Machine Learning in Early Diagnosis

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### ABSTRACT

Early detection of bone cancer plays a crucial role in improving patient outcomes and survival rates. In recent years, machine-learning techniques have emerged as promising tools for enhancing the accuracy and efficiency of cancer detection. This paper explores the application of machine learning algorithms in the early detection of bone cancer. By leveraging large datasets of medical images, such as X-rays, CT scans, and MRI scans, machine learning algorithms can identify patterns and features indicative of bone cancer. These algorithms assist radiologists and clinicians in the timely diagnosis and treatment planning for patients. This paper discusses the obstacles and possibilities associated with using machine learning in bone cancer detection, including data availability, algorithm selection, and validation. Furthermore, it highlights the potential impact in using machine learning for improving early detection rates, leading to more effective interventions and improved patient outcomes. Overall, this paper showcases the advancements in the early detection of bone cancer through the integration of machine-learning techniques, emphasizing the potential for significant advancements in the field of oncology.

**Keywords:** Machine learning, Bone Cancer, Early Detection, Challenges, Opportunities.



**Anna Diana and Prakash**

## INTRODUCTION

Bone cancer, a malignant tumor originating in the skeletal system, poses a significant threat to individuals worldwide. Its sneaky character, which frequently goes unnoticed at the beginning, contributes to delayed diagnoses and, consequently, diminished treatment efficacy. The critical need for timely identification of bone cancer has spurred the exploration of innovative diagnostic methodologies, with machine learning emerging as a transformative force within the field of research in medicine. Traditional diagnostic approaches, reliant on radiological imaging and histopathological analysis, have demonstrated limitations in sensitivity and specificity, particularly when faced with subtle manifestations of bone cancer during its emerging phase. The integration of machine learning algorithms into the diagnostic landscape presents a promising avenue to address these challenges. By harnessing the capability of artificial intelligence, these systems can process vast datasets, recognize complex patterns, and unveil subtle anomalies indicative of early-stage bone cancer. This paper seeks to explore the growing field of detecting bone cancer with machine learning methods. We research into the basis behind this model modification, examining the limitations of current diagnostic methodologies and the potential benefits of incorporating machine-learning algorithms into the diagnostic workflow. Furthermore, we review recent advancements, methodologies, and case studies that underscore the effectiveness by means of machine learning for the timely and accurate identification of bone cancer.

## LITERATURE REVIEW

A comprehensive literature review underscores the significance of early detection in augmenting patient outcomes for bone cancer. Prior studies emphasize some methods for machine learning in discerning subtle patterns indicative of bone cancer at an early stage. The review also delves into existing challenges, such as limited data availability and algorithmic complexities that accompany the usage of algorithms for learning in the domain of oncology. Most commonly employed in machine learning are the Random Forest technique and SVM (Support Vector Machine). Ashish Sharma [1] states that while diagnosing human bone diseases, SVM performs the best also the SVM model trained with hog feature set provides an F1-score of 0.92 better than Random forest F1-score 0.77. Bone cancer, though relatively rare, poses significant challenges in early diagnosis, emphasizing the need for innovative approaches. According to Srivastava, D [2] the main difficulty in using machine learning to diagnose bone cancer is figuring out how to best utilize the structure of medical imaging and particular characteristics of medical data for model building and training. The precision and prognostic machine learning's potential techniques for medical image processing require further development. Recent advancements in machine learning have sparked considerable interest in its application to improve early detection rates and patient outcomes. Anand et al (2021) [3] utilized a Convolutional Extreme Learning Machine (DC-ELM) method for the assessment of cancer kind based on evaluating histopathology photos. The accuracy of the DC-ELM algorithm is 97.27%.

Several studies have shown that machine learning is effective at detecting bone cancer early. Gitto et al. (2020) [4] created a categorization model that could potentially assist radiologists in communicating the likelihood that a cartilaginous bone tumor is low-to-high grade by including histology data and guiding medical professionals toward a conservative or aggressive course of action. Similar to Ashish Sharma's work, Shrivastava A et al. (2023) [5] conducted a comparison analysis utilizing the SVM and Random Forest algorithms, except they added hog to the bone. They concluded that performance is greatly improved by adding HOG, which improves the ability to distinguish between both malignant and healthy bone. In a similar vein Johnson et al. (2020) [6] concentrated on the combination of multi-modal data, merging radiographic pictures with genetic and molecular details. Their work showcased the capacity to utilize machine learning in leverage diverse datasets, leading to enhanced sensitivity and specificity in diagnosing various types of bone cancers. Despite promising advancements, applying machine learning in bone cancer diagnosis faces several challenges. Data limitations, as discussed by Chen et al. (2018) [9], hinder the



**Anna Diana and Prakash**

development of robust models. The scarcity of diverse and well-annotated datasets impedes the machine learning's generalizability applications across different patient demographics and cancer subtypes.

## MATERIALS AND PROCEDURES

### Data Collection

Collaboration with leading medical institutions facilitated the acquisition of diverse datasets encompassing medical images, patient records, and clinical histories. Rigorous adherence to ethical standards and privacy regulations governed the entire data collection process. The mentioned figure is an example of how the MRI image which is the data is been used to detect the bone cancer.

### Data Preprocessing

Data preprocessing involved comprehensive cleaning, normalization, and feature extraction procedures. Anonymization protocols were implemented to ensure the confidentiality and privacy of patient data. The main phases in data preprocessing include data cleaning, data transformation, data reduction, and data integration. Among the most significant preprocessing stages in machine learning is data cleaning, which finds and corrects flaws or discrepancies in the data. In Data Integration, information gathered from many sources are integrated (merged) in this procedure to outline and produce a single dataset. Typical data transformation techniques include normalization, standardization, and discretization. Normalization scales data to a common range, whereas standardization alters data to have a zero mean and unit variance. The technique of reducing the amount of a dataset without losing important information is known as data reduction.

### Model Development

Utilizing the Python programming language and frameworks such as Tensor Flow, the research team designed and implemented machine-learning models. Convolutional Neural Networks (CNNs) were selected for their efficacy in image classification tasks related to bone cancer detection. Random Forest and Support Vector Machine (SVM) systems are also considered appropriate for image-based detection. In most cases, SVM is considered more accurate than Random Forest.

### Convolutional Neural Networks (CNNs)

CNNs are particularly effective for image-based tasks. They consist of convolutional layers that automatically learn hierarchical representations of features. CNNs have been successful in tasks such as image classification, segmentation, and object detection.

### Support Vector Machines (SVM)

SVMs are traditional but powerful models used for classification tasks. They work well for both linear and non-linear classification and is applicable to feature vectors derived from medical images.

### Random Forests and Decision Trees

Ensemble methods like Random Forests can be useful for combining multiple decision trees to improve overall predictive performance. These techniques can be employed when dealing with multi-modal data or when interpretability is crucial. It is important to note that the choice of a specific machine-learning model depends on the qualities of the information, the intricacy of the problem, and the available computational resources. Additionally, model performance should be rigorously evaluated using appropriate metrics, and continuous refinement may be necessary to improve accuracy and generalization.

### Validation and Testing

To evaluate model performance, distinct datasets were prepared for validation and testing phases. Rigorous evaluation metrics, including ROC curve study, F1 score, recall, accuracy, and precision, were applied to assess the model's effectiveness in early detection.



**Anna Diana and Prakash****Data Availability**

Collaborative efforts with healthcare institutions and using made-up data hold promise for addressing limited and imbalanced datasets.

**Algorithm Selection**

Experimentation with various architectures and continuous updates can help overcome challenges related to complex bone structures and varied imaging modalities.

**Validation**

The implementation of explainable AI methods and involving healthcare professionals in the validation process are crucial for addressing over fitting and ethical concerns. In conclusion, while challenges exist in data availability, algorithm selection, and validation processes for bone cancer detection, collaborative approaches, technological experimentation, and a commitment to transparency can unlock significant opportunities for the advancement machine learning in this critical healthcare domain. The high accuracy and precision of the developed machine-learning model underscore its potential as a useful instrument for clinicians. Early detection rates are improved, contributing to enhanced diagnostic precision and timely interventions.

**Future Directions**

Future Directions To overcome these challenges, future research directions should prioritize diversification of datasets. Efforts to create well-curated, diverse datasets can improve model generalizability and address data limitations. Longitudinal studies, as proposed by Liu et al. [8] (2023), should explore the progression of bone cancers over time, providing valuable insights into the evolution of these diseases and guiding the development of predictive models. Research into Explainable AI (XAI), as suggested by Sharma and Gupta [7](2024), should be prioritized to enhance the interpretability models for machine learning, fostering clinician trust and facilitating better understanding. The integration of molecular and genetic data offers a promising avenue for advancing personalized medicine in bone cancer diagnosis. By combining radiological information with the above-mentioned data, researchers can unravel complex cancer biology and identify novel diagnostic markers. Future research directions should include

1. Exploration of diverse datasets to enhance model generalizability.
2. Continuous model learning to adapt to evolving datasets and medical knowledge.
3. Collaboration with healthcare professionals for real-world validation.

**CONCLUSION**

The paper contributes to the expanding body of research on machine learning-based early bone cancer detection. It has delved into the challenges and opportunities inherent in utilizing machine learning for bone cancer detection. From navigating issues related to data availability and algorithm selection to emphasizing the crucial aspect of validation, the discussion has underscored the complexities involved in integrating machine learning into this critical domain. Nevertheless, the potential impact on early detection rates and subsequent improvements in interventions and patient outcomes cannot be understated. As advancements continue to unfold, embracing machine learning within the framework of bone cancer detection represents a possible route for revolutionizing the field of oncology. The future holds the prospect of more effective diagnostic tools and enhanced patient care, highlighting the transformative power using machine learning in advancing healthcare practices.

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**Anna Diana and Prakash**

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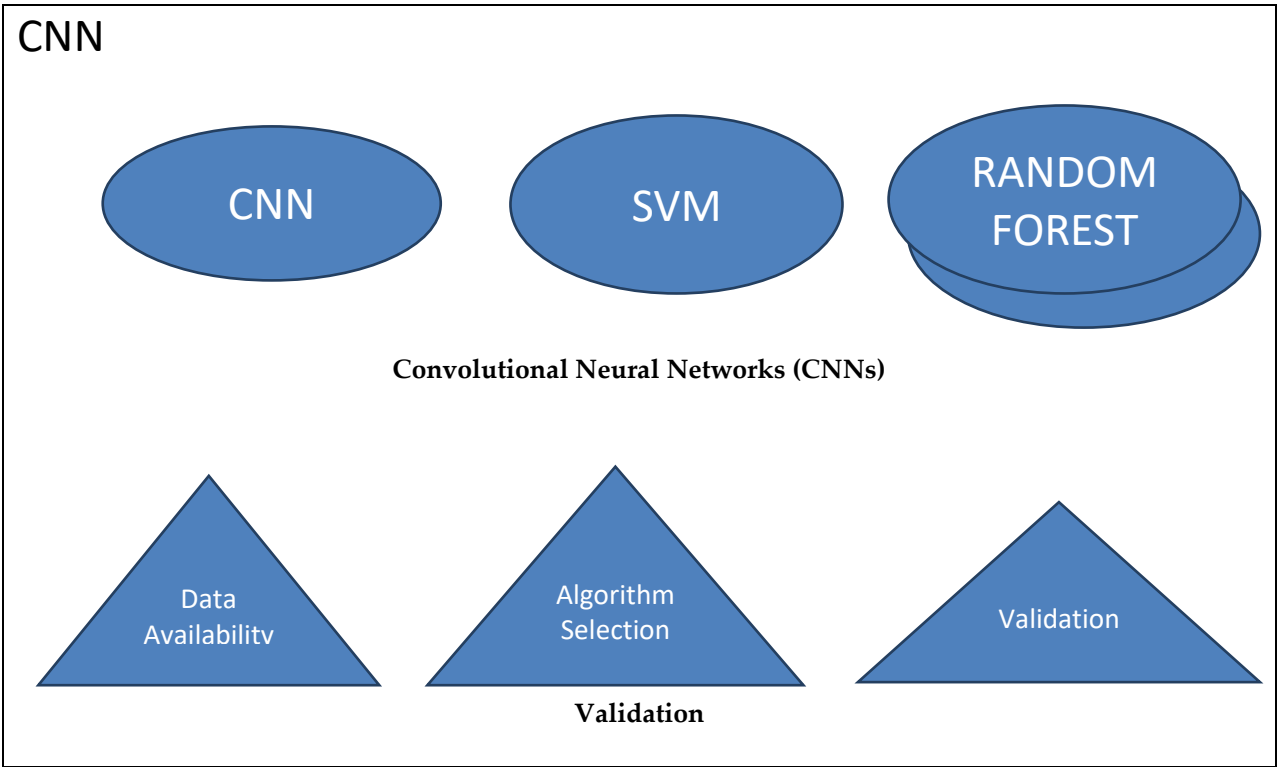
**Results and Conclusion**

<b>Challenges and Opportunities in Bone Cancer Detection</b>		
<b>Aspect</b>	<b>Challenges</b>	<b>Opportunities</b>
Data Availability	Limited and imbalanced datasets may hinder generalization.	Collaboration with healthcare institutions for data sharing. Synthetic data generation and augmentation.
Algorithm Selection	Complex bone structures and varied imaging with different modalities require sophisticated models	Experimentation with different architectures and transfer learning. Regular updates based on technological advancements.
Validation	Over fitting, lack of interpretability, and ethical considerations pose challenges during validation	Explainable AI to enhance transparency, involvement of healthcare in professionals in model validation.





**Anna Diana and Prakash**





## Transforming the Banking Sector: The Rapid Adoption of IoT

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### ABSTRACT

The Internet of Things (IoT) has emerged as a disruptive force in various industries, including banking. This article examines the transformative impact of IoT on the banking sector, focusing on its rapid adoption and the implications for financial institutions. By leveraging IoT technologies, banks can enhance operational efficiency, improve customer experience, and unlock new revenue streams. This study explores the key IoT applications in banking, such as smart branches, wearable devices, and connected ATMs. Additionally, it discusses the challenges and potential risks associated with IoT adoption, including data security and privacy concerns. By addressing these challenges and embracing IoT, banks can position themselves at the forefront of innovation and gain a competitive edge in the digital era.

**Keywords:** Internet of Things, banking sector, digital transformation, smart branches, operational efficiency, customer experience, data security

## INTRODUCTION

The advent of the Internet of Things (IoT) has brought about a significant transformation in various sectors, revolutionizing how organizations operate and interact with their customers. The banking sector is no exception, as it recognizes the potential of IoT to reshape traditional banking practices and deliver enhanced financial services. This article aims to provide insights into the rapid adoption of IoT in the banking industry, highlighting its applications, benefits, challenges, and implications for financial institutions. In recent times, the banking and financial industry has witnessed a significant rise in its importance. The convergence of business automation, transformed transactions, and client management has paved the way for the integration of Internet of Things (IoT) in the Fintech industry, yielding fruitful results. Numerous banking and finance organizations are embracing IoT technology to establish themselves as influential market leaders. By leveraging IoT, these institutions can effectively convert vast amounts of information into actionable insights, empowering them to make well-informed decisions



**Jithin Scaria and Rinku K Vithayathil**

The adoption of IoT in the banking and finance sector has brought forth various advantages. One notable benefit is the ability to transform raw data into valuable insights. IoT devices and sensors are employed to collect real-time data, which is then analyzed and interpreted to generate actionable information. This wealth of insights aids in strategic decision-making, enabling banks and finance companies to enhance their operational efficiency and overall performance. One key application of IoT in the industry lies in customer management. Through the utilization of IoT technology, banks can monitor customer behavior and preferences, facilitating the provision of personalized services tailored to individual needs. This personalized approach not only boosts customer satisfaction but also cultivates customer loyalty, contributing to the long-term growth and success of the business.

Additionally, IoT devices have played a crucial role in revolutionizing transactions, making them more secure and efficient. Integration of IoT-enabled payment devices and systems ensures seamless and contactless transactions, minimizing the risk of fraudulent activities while enhancing convenience for customers. Furthermore, IoT has become instrumental in risk management and security within the banking and finance sector. IoT devices are capable of real-time monitoring and detection, allowing banks to promptly identify potential security breaches or fraudulent activities. This proactive approach enables immediate action to be taken, mitigating financial losses and safeguarding the institution's reputation. It is essential to acknowledge that alongside the benefits, the adoption of IoT in the banking and finance industry also poses certain challenges. These include ensuring data security and privacy, managing the complexity of IoT infrastructure, and addressing interoperability issues. Banks and finance organizations must prioritize robust cyber security measures, adhere to data protection regulations, and invest in the necessary technological infrastructure to overcome these challenges successfully. The integration of IoT technology has significantly impacted the banking and financial industry. By leveraging IoT's capabilities, banks and finance companies can gain actionable insights, enhance their decision-making processes, and stay ahead in the competitive market landscape. As the digital era continues to evolve, embracing IoT offers immense opportunities to drive growth, improve operational efficiency, and deliver exceptional experiences to customers in the banking and finance sector.

**IoT Applications in the Banking Sector****Smart Branches**

IoT technology has revolutionized the banking industry by enabling the creation of smart branches that utilize advanced technologies to streamline operations and enhance customer experience. These smart branches leverage IoT devices to monitor footfall, analyze customer behavior, and optimize staffing requirements, resulting in improved operational efficiency and resource utilization. One of the key benefits of smart branches is the ability to provide personalized services to customers. Through the integration of IoT devices such as digital signage, interactive kiosks, and intelligent chatbots, banks can deliver tailored information and assistance based on individual customer needs. This level of personalization enhances customer engagement and satisfaction, as customers receive relevant and timely support during their banking interactions. By utilizing IoT sensors, smart branches can monitor footfall and customer traffic patterns in real-time. This data allows banks to analyze customer behavior, identify peak hours, and optimize staff allocation accordingly. As a result, banks can ensure that the right number of staff members is available during busy periods, reducing customer waiting times and improving overall service quality. Furthermore, IoT-enabled devices within smart branches facilitate self-service options for customers. Interactive kiosks equipped with IoT capabilities can provide customers with access to a wide range of services, including account inquiries, fund transfers, and loan applications. These self-service options not only empower customers to perform transactions independently but also reduce the workload on bank staff, enabling them to focus on more complex inquiries and personalized assistance. IoT-enabled smart branches have transformed the banking landscape by integrating advanced technologies to streamline operations and enhance customer experience.

**Wearable Devices**

The rise of wearable devices, including smart watches and fitness trackers, has created a new avenue for delivering banking services. Banks can harness the power of IoT-enabled wearable to provide a range of convenient and personalized financial experiences to their customers. By leveraging IoT technology, wearable devices can deliver



**Jithin Scaria and Rinku K Vithayathil**

real-time notifications to users regarding their financial transactions, account balances, and important updates. This ensures that customers are always informed and can stay on top of their financial activities effortlessly. Furthermore, wearable devices can offer personalized financial insights based on individual user data. By integrating with banking systems and utilizing IoT-generated data, wearable can provide tailored recommendations for budgeting, saving, and investment strategies. This level of personalization empowers customers to make informed financial decisions and improve their financial well-being. Security is a critical aspect of banking, and IoT-enabled wearable play a role in enhancing it. These devices can facilitate authentication and authorization processes, enabling secure access to banking services. This ensures that customer data and financial information remain protected. Additionally, wearable enable contactless payments, offering a seamless and secure transaction experience. With built-in NFC (Near Field Communication) technology, wearable can facilitate quick and secure payments at compatible point-of-sale terminals. This eliminates the need for physical cards or cash, further enhancing convenience and reducing the risk of card fraud or theft. By embracing wearable technology, banks can provide customers with convenient, personalized, and secure banking experiences, ultimately improving customer satisfaction and loyalty.

**Connected ATMs**

The integration of IoT technology with ATMs brings several advantages that enhance their functionality and efficiency. By enabling remote monitoring and predictive maintenance, IoT integration minimizes downtime and improves overall operational efficiency. Connected ATMs can proactively detect maintenance needs, allowing for timely repairs or replacements, which reduces the risk of unexpected failures and ensures uninterrupted service for customers. Additionally, IoT connectivity enables ATMs to continuously monitor cash levels and transmit real-time data to banks, facilitating effective cash management and ensuring that ATMs are adequately stocked. Moreover, IoT integration empowers ATMs to offer personalized services tailored to individual customer preferences and historical data. By leveraging IoT-generated insights, ATMs can present targeted offers, provide personalized recommendations, and even customize the user interface to align with the customer's preferred language or transaction preferences. This personalized approach enhances the banking experience, making transactions more convenient and relevant to the customer's needs. Overall, IoT integration with ATMs improves operational efficiency, reduces downtime, enhances cash management, and enables personalized services. These benefits not only optimize the functioning of ATMs but also contribute to a better customer experience, ultimately strengthening customer satisfaction and loyalty.

**Benefits of IoT Adoption in Banking****Operational Efficiency**

The adoption of IoT technologies in the banking industry brings numerous benefits, including the automation of routine tasks, process optimization, and the reduction of manual errors. IoT-enabled devices, such as sensors and connected systems, can collect and transmit data in real-time, providing banks with valuable insights for decision-making and resource allocation. By automating routine tasks through IoT, banks can free up human resources from repetitive and time-consuming activities. This allows employees to focus on more complex and strategic tasks, such as providing personalized customer service and conducting in-depth data analysis. As a result, overall operational efficiency is improved, leading to increased productivity and cost savings. IoT technology also enables banks to optimize processes by monitoring and analyzing data from various sources. For example, IoT sensors can track and analyze customer behavior, enabling banks to identify patterns and trends in their preferences and needs. This information can be used to tailor products and services, enhance customer experiences, and drive customer engagement and loyalty. Additionally, the real-time data collected by IoT devices allows banks to make data-driven decisions and allocate resources effectively. By having access to up-to-date information on customer demand, transaction volumes, and operational performance, banks can optimize staffing levels, inventory management, and service delivery. This result in streamlined operations, reduced costs, and improved customer satisfaction.

**Enhanced Customer Experience**

IoT-driven innovations enable banks to deliver personalized, context-aware services to their customers. With IoT-enabled devices, banks can offer tailored product recommendations, real-time financial advice, and personalized



**Jithin Scaria and Rinku K Vithayathil**

marketing campaigns. Additionally, IoT-powered customer service tools enable seamless interactions, such as voice-activated assistants and chat bots, enhancing customer satisfaction and loyalty.

**New Revenue Streams**

The adoption of IoT expands the realm of banking services, creating opportunities for innovative revenue streams. Banks can leverage IoT data to develop value-added services, such as financial planning, insurance, and smart home solutions. Moreover, partnerships with IoT device manufacturers and technology companies can open up avenues for collaborations and revenue-sharing models.

**Challenges and Risks of IoT Adoption in Banking****Data Security and Privacy**

The rapid adoption of IoT introduces significant concerns regarding data security and privacy. Banks need robust cyber security measures to safeguard sensitive customer information and prevent unauthorized access. Additionally, data privacy regulations must be adhered to, ensuring transparent data collection and usage practices to maintain customer trust.

**Interoperability and Integration**

Integrating IoT devices and platforms with existing banking infrastructure can be challenging due to the diverse ecosystem of technologies and standards. Banks must ensure interoperability between IoT devices, back-end systems, and third-party applications to achieve seamless data exchange and integration. This requires careful planning, standardization efforts, and collaboration with technology partners.

**Scalability and Cost**

Scaling up IoT deployments across a bank's network can be complex and costly. Banks must consider the infrastructure requirements, connectivity issues, and maintenance costs associated with large-scale IoT implementation. Furthermore, IoT solutions must demonstrate a clear return on investment to justify the initial and ongoing expenses.

**Implications for Financial Institutions**

The rapid adoption of Internet of Things (IoT) technology in the banking sector has brought about transformative changes and has far-reaching implications for financial institutions. To stay competitive in today's digital era, banks need to embrace digital transformation and invest in IoT capabilities. This entails fostering a culture of innovation, up skilling employees, and forming strategic partnerships with technology providers. By leveraging IoT technologies effectively, banks can unlock new business opportunities, enhance customer relationships, and position themselves as leaders in the digital banking landscape. The adoption of IoT in the banking sector opens up new avenues for innovation and growth. By leveraging IoT devices, banks can collect and analyze vast amounts of real-time data, allowing them to gain valuable insights into customer behavior, preferences, and needs. These insights can be utilized to develop personalized products and services, tailored to individual customers, thereby enhancing the overall customer experience. For example, IoT-enabled wearable devices, such as smart watches, can provide customers with real-time notifications, personalized financial insights, and secure payment options, leading to increased customer satisfaction and loyalty.

Moreover, IoT technologies enable banks to optimize their operational efficiency. By integrating IoT devices into their infrastructure, banks can automate various processes, streamline operations, and reduce costs. For instance, connected ATMs equipped with IoT capabilities can provide remote monitoring, predictive maintenance, and personalized services based on customer preferences. This not only improves the efficiency of ATM management but also enhances the customer experience by offering customized services and ensuring seamless transactions. In addition, IoT adoption in the banking sector presents new business opportunities and revenue streams. The data collected from IoT devices can be analyzed to identify patterns, trends, and customer insights, which can be monetized through value-added services. For example, banks can leverage IoT data to develop personalized





**Jithin Scaria and Rinku K Vithayathil**

financial planning tools, offer targeted advertisements, or even collaborate with IoT device manufacturers to provide exclusive offers and discounts to customers. By capitalizing on the potential of IoT-generated data, banks can generate additional revenue and expand their business scope. To fully leverage the potential of IoT, banks must invest in upskilling their workforce and fostering a culture of innovation. Employees need to be trained to understand and utilize IoT technologies effectively. This includes developing skills in data analysis, cyber security, and IoT infrastructure management. Additionally, banks should encourage a culture of innovation that embraces experimentation, collaboration, and the continuous exploration of new IoT applications. Furthermore, banks should establish strategic partnerships with technology providers to access cutting-edge IoT solutions. Collaborating with IoT experts and vendors can help banks overcome the challenges associated with IoT implementation, such as interoperability, security, and scalability. By forming these partnerships, banks can leverage the expertise and resources of technology providers to accelerate their IoT adoption journey and stay at the forefront of technological advancements. The transformative power of IoT in banking is immense, and banks that seize this opportunity can gain a significant competitive advantage in the evolving financial industry.

**CONCLUSION**

The rapid adoption of IoT in the banking sector presents a transformative opportunity for financial institutions. By leveraging IoT applications such as smart branches, wearable devices, and connected ATMs, banks can enhance operational efficiency, improve customer experience, and explore new revenue streams. However, challenges related to data security, interoperability, and scalability must be addressed to fully realize the potential of IoT in banking. With careful planning, investment, and collaboration, banks can navigate these challenges and lead the way in the digital era, driving innovation and delivering value to their customers.

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## Integrated Floating Agriculture – Aquaculture: A Sustainable Approach for Kerala's Self-Sufficiency and Livelihood Enhancement – A Conceptual Model

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### ABSTRACT

Floating agriculture is an environment friendly option for increasing the land for agriculture. As such, the practice could be sustainable and profitable in developing countries, helping to supplement incomes and to increase food security. Regular, land-based agriculture requires farmland to be protected behind embankments. This activity can have detrimental side effects upon the local environment and economy. Floating agriculture can be conducted without land. The procedure can even contribute toward maintaining healthy wetlands which have coastal defence functions and also support a wide range of biodiversity. The practice is already widely applied in some countries such as Bangladesh and the uptake of the technology is already increasing due to its sustainable positive features. Results shows that adoption of this system is possible as a strategy to increase productivity or to raise livelihood and food security among poor people wherever no access to land or productions inputs are available. It excludes irrigation tasks, better pest control than conventional farming and productivity in flood prone areas makes floating an interesting option to reduce the impact of climate change. The cost-free organic fertilization in aquaculture water could sensitively increase farm productivity by improving both fish and vegetable production. The possibility to develop agriculture on water bodies would undoubtedly open up opportunities to raise the income, livelihood and food security of people in Kerala.

**Keywords:** Floating agriculture – aquaculture, Sustainability, Self-sufficiency, livelihood enhancement, food security, biodiversity



**Antony George and Jissmol Vaghese**

## INTRODUCTION

Kerala is a state on India's tropical Malabar coast which has nearly 600km of Arabian sea shore line. It is known for its palm-lined beaches and back waters, a network of canals. Kerala is topographically and ecologically diverse, consisting of coastlands, wetlands and hills, Western Ghats etc. Agriculture in Kerala is now declining due to the changed lifestyle and mind-set of the people. Kerala relies heavily on other states for food grains even though the state is abundantly blessed with resources to cater the needs of its own people. From grains, fruits, vegetables to other food essentials, Kerala's consumerist society is deeply a dependent one. Due to the dependence on other states for food grains, sometimes Kerala used to face shortage of food products which leads to price rise and consumer woes. During the lockdown as a part of the world pandemic Covid19, Kerala faced the situations where Karnataka closed its borders with the Kasar god district of Kerala as it was a hotspot. Kerala has enough food stocks available for now and is in a comfortable situation. However, if the current circumstances do not continue for long, the state needs to start preparing for the future and would need big interventions in the agriculture sector. Kerala is also facing a difficulty in producing the agricultural products due to the frequent flood and climate changes which has taken place over the last 3 years. Due to this disruption also farmers found it difficult and not profitable to continue the production. The idea to promote self-sufficiency should be convenient and less affected by the climatic changes and thereby provide a better standard of living to the farmers. So, to become self-sufficient we can adopt integrated floating agriculture and aquaculture.

## REVIEW OF LITERATURE

This growing system is seen today as a strategy to diversify production in common property wetlands and to cope with climate change effects wherever flooding makes land unavailable for agriculture for long periods (Parvej, 2007). In Asia, such systems are mainly made with water weeds piled together to add buoyancy and left decaying for a few weeks to make them a fertile support for plants (Haq et al., 2004; Parvej, 2007). Rafts were loaded with compost or manure as the top layer, which was an ideal substrate for seedlings, increased raft nutrient pools, and reduced evaporation (Haq et al., 2004; Haq et al., 2005; Islam and Atkins, 2007). The nutrient content of some of these floating beds showed ammonia levels between 60 to 282 ppm against a reference value of 150 ppm of nitrogen for good-quality vegetable production (Islam and Atkins, 2007). Potassium was in excess or at optimal levels while phosphorus, manganese, and iron concentrations were low. Organic matter levels were quite high with values ranging from 20.7% to 42.8% and pH from 6.9 to 7.4 (Islam and Atkins, 2007). Floating agriculture in integrated agriculture aquaculture systems (IAAS) can support the nutrient balance of pond water, where chemical or natural fertilization occurs to improve primary production (Diana et al., 1997). Leaching of nutrients from organic matter or manure is a cost-free practice among poor smallholders to increase plankton blooming for feeding planktivorous fish and increase pond yields (Prein, 2002). Furthermore, plant production in aquaculture water can be used as a bioremediation tool to reduce high nitrogen levels in more intensive aquaculture operations, as in the case of aquaponics (soilless plant production on aquaculture water) (Rakocy and Hargreaves, 1993). In addition, the cost-free organic fertilization in aquaculture water could sensitively increase farm productivity by improving both fish and vegetable production. IAAS in Africa has proved that farmers who own ponds are more resilient to drought conditions and can diversify production (Prein and Ahmed, 2000). Integration of agriculture with ponds is a good strategy in Asia to raise livelihood during critical seasons, improve household fish consumption, and open market access to farmers (Prein and Ahmed, 2000; Prein, 2002). Impact indicators on income and productivity show that ponds can sustainably double farm incomes (Dey et al. 2007) and grant better life standards.

### Need for the Study

Statistics show that Kerala has huge amount of waterlogged areas especially in the coastal region. This study makes an effort to create sustainable food security by efficiently and effectively using water-logged areas in Kerala. The present integrated farming systems are the following which can be used in own land.



**Antony George and Jissmol Vaghese**

1. Rice-fish integrated system
2. Live stock fish system
  - Cattle-fish system
  - Pig-fish system
  - Poultry-fish system
  - Duck-fish system
3. Horticulture-fish system

These systems do not take into consideration effective and efficient use of thousands of hectares of naturally water-logged areas in Kerala. Floating agriculture is used in some parts of Asia and Floating aquaculture in some parts of Asia and Europe, but not an integrated one. This study aims to provide a conceptual idea of integrated floating agriculture-aquaculture which can be helpful for the proper utilization of water-logged areas.

**Objectives of the study**

1. How floating agriculture can address the issue of food security in Kerala
2. Investigate the environmental impact of floating agriculture and how it compares to traditional farming methods.
3. Examine the economic feasibility of implementing floating agriculture in different regions.
4. How the water-logged areas in Kerala can be made useful for sustainable food production.

**Wetland**

The major wetland types are River/Stream (65162 ha), Lagoons (38442 ha), Reservoirs (26167 ha), and waterlogged (20305 ha). Compared to coastal land, the highland and middle land hold very few wetlands. The state consists of 160.6 thousand hectares (ha) of wetlands i.e. 4.13 percent of the state. There are a total of 4,354 wetlands of which 2,592 are mainly wetlands with areas less than 2.25 ha each. The rest of the 1,762 wetlands are divided into two types-inland and coastal. Kerala has 169 natural coastal wetlands with a total area of 40.9 thousand ha. There are 1,593 inland wetlands with a total area of 117.1 thousand ha.

**Floating Agriculture**

For more than 20 years, floating agriculture has shown to be a profitable farming method. Bangladesh has advocated for its application in a number of areas to enhance food security, offer substitute means of subsistence, lower the risk of disasters, and prepare for climate change. Mesoamerica and Southeast Asia have been using this technique for thousands of years; it predates modern agriculture. Farmers can cultivate crops in flooded locations where typical land use is impractical thanks to floating agriculture. The method entails long-term food production in places flooded by water, with the main goal being adaptation to increasing or longer flooding. Compost from decaying plant beds is used in this approach to support crop growth. In locations that are flooded, these beds have the ability to float on the water's surface, forming pockets of arable land. Floating agriculture is a way of producing food in areas that are water logged for a long period. It is mainly aimed at adapting to increased or prolonged flooding. System employs beds of rotting vegetation that act as compost for crop growth. The beds are able to float on the surface of the water, thus creating areas agricultural land in a water logged area. Scientifically floating agriculture can be referred to as hydroponics. Floating agriculture is reasonably widespread in Bangladesh, where agricultural land is inundated for extended periods during the monsoon season (APEIS & RIPS0 2004).

**Aquaculture**

Aquaculture refers to the practice of farming aquatic organisms, such as fish, mollusks, crustaceans, and aquatic plants. Among these, fish farming is the most widely adopted method, wherein fish are raised commercially in tanks, fish ponds, or ocean enclosures, primarily for consumption. The state of Kerala boasts abundant freshwater resources that are well-suited for aquaculture.

**Integrated Floating Agriculture – Aquaculture**

**Antony George and Jissmol Vaghese**

The most effective strategies for enhancing the productivity of small-scale farming in rural areas with limited resources. When a farmer diversifies production by combining livestock, fish, tree, crops, and vegetables, farm production is steady and efficient in terms of resource consumption and environmental conservation. Floating agriculture-aquaculture is the integration of agricultural farming and fish farming in the water-logged areas, where land availability is low. In this concept floating agricultural beds are made with water hyacinths, bamboo, Cow-dunk, and dirt/sand. Vegetables are planted on the surface of water using these floating beds and fishes are grown beneath the water.

**Implementation**

Floating agriculture usually consists of a layer of water hyacinth, straw, or rice stubble floating on the surface, to which upper layers of small, rapidly decomposing water worts are added. These water worts provide excellent manure (APEIS & RIPSO 2004). Bamboo is used to reinforce the floating raft structure and to secure it in place so that damage from drift or wave movement is prevented. After that, the floating raft can be moved for farming to any submerged area for agricultural purposes. Gathering water hyacinth is the first stage in creating a floating raft. Bamboo poles cut to the right length for the size of the raft being built are placed over floating water hyacinth, and this mass of plant material is then brought to one bank to be worked on. With the help of stick hooks, more water hyacinth is gathered and added to the bamboo layer. Once the fundamental framework of the raft has been established, the bamboo poles can be extracted. To top off the current structure, additional water hyacinth is added after around seven to ten days. To cover the raft's base, soil, compost, and cow dung are added and seeds can be sown. Producing crops include lady fingers, brinjal, onions, pumpkins, and green vegetables. The raft will eventually deteriorate and become unusable. At the conclusion of the growing season, the rafts are typically disassembled and turned into compost, and a fresh raft is ready for the following harvest. Fish can be grown beneath the water when vegetables are planted on the water's surface. By consuming the agricultural waste, fish can thrive, and the fish will also provide enough fertilizer for the floating bed. This will support the expansion and increased production of aquaculture and agriculture, respectively.

**Working Principle**

Man-made floating islands of matted organic material are used to replace labour-intensive watering systems and land across freshwater bodies. Plants are anchored and rooted over these materials, and their roots grow into the lake below, providing them with an endless supply of fresh water. This growing method is completely resistant to flooding, as the island rises and falls with the water level.

**Cost Factor**

The raw materials used for building floating beds are bamboo poles, water hyacinth, coconut husk, etc are easily available and thus the cost will be very cheap. In aquaculture, the amount required for cages will be 3 lakh which includes 1.8 lakh as operational cost. There is a grant of 40% of unit cost for new units and 20% of operational cost for the already established unit.

**Advantages Of Floating Agriculture And Aquaculture**

1. More food is produced for human consumption;
2. The total cultivable area can be increased;
3. The area under floating cultivation is more fertile than traditional land;
4. No additional fertilizers or manure is needed, unlike in the conventional agricultural system;
5. The biomass generated after cultivation can be used as organic fertilizer in the field;
6. It conserves the environment;
7. It can be used as a shelter for cattle and poultry during floods; and • Fishermen can cultivate crops and fish simultaneously.





**Antony George and Jissmol Vaghese****Environmental Benefits**

1. Climate change adaptation technologies
2. Floating agriculture is a sustainable and ecologically beneficial form of agriculture
3. Reducing mosquito breeding grounds and enhancing conditions for open-water fishing by using water hyacinth, a highly invasive weed with rapid growth rates;
4. Avoiding chemical fertilizers and preventing environmental harm by not introducing pollutants into water;
5. Using platform residues as organic fertilizer, a practice that reduces pollution from chemical fertilizers

**Socio-Economic Benefits**

In place of land lost to flooding, it provides an alternative growing space. It is also ten times more productive than conventionally farmed land and doesn't need extra fertilizer or manure.

Farmland that is used for regular land-based agriculture must be reclaimed from estuaries or protected behind embankments.

**Agricultural Benefits**

1. More space for growing vegetables and raising seedlings in wetlands;
2. Early production of winter vegetable seedlings;
3. Increased availability of vegetables in the surrounding areas;
4. Crops require less time to mature when grown on floating platforms;
5. Water hyacinth contains prime nutrients like nitrogen, phosphorus, and potassium that are comparable to those found in cow dung.

**CONCLUSION**

An environmentally friendly way to expand the amount of land used for agriculture is through floating agriculture. Because of this, the method may be profitable and sustainable in poor nations, contributing to increased food security and revenue augmentation. Farmland needs to be sheltered by embankments in order to practice regular, land-based agriculture. There may be negative side effects from this activity on the local economy and ecology. It is possible to carry out floating agriculture without any land. Even better, the process can help preserve healthy wetlands that support a diverse array of wildlife and serve as a kind of coastal defence. In certain nations, like Bangladesh, the practice is already extensively used, and because of the technology's long-term advantages, adoption of the system is already rising. The findings indicate that this approach can be adopted as a means of raising food security and livelihood standards for the impoverished or increasing productivity in areas where land or production inputs are unavailable. Floating farming is an intriguing way to lessen the effects of climate change because it eliminates the need for irrigation, has superior pest management than conventional farming, and is productive in locations that are vulnerable to flooding. Free organic fertilization in aquaculture water has the potential to improve vegetable and fish yields while also subtly raising farm output. The potential for agriculture to grow on water bodies would surely present chances to improve the food security, livelihood, and income of Kerala's impoverished and landless population. Floating agriculture showed competitive advantages over soil-based agriculture. Improved tolerance to salt, easier management that excludes irrigation tasks, better pest control than conventional farming, and productivity in flood-prone areas make floating agriculture an interesting option to reduce the impact of climate change. The possibility of developing agriculture on water bodies would undoubtedly open up opportunities to raise farm income, livelihood, and food security for poor and landless people who can benefit from locally available materials and by-products to run sustainable farming. This technology has made it possible to ensure nutrition by producing food. Along with that, food is within the reach of people. If the modern technology of floating agriculture is expanded, it will be possible to ensure the nutrition of the common people by increasing the food production of the state.





**Antony George and Jissmol Vaghese**

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**Table1: Type-wise wetland distribution in Kerala**

Wetland Category	Number of Wetlands	Total Wetland Area	% of wetland area	Open water	
				Post monsoon	Pre monsoon
Inland Wetlands - Natural					
Lakes/Ponds	3	2643	1.65	2259	2125
Riverine wetlands	18	410	0.26	410	410

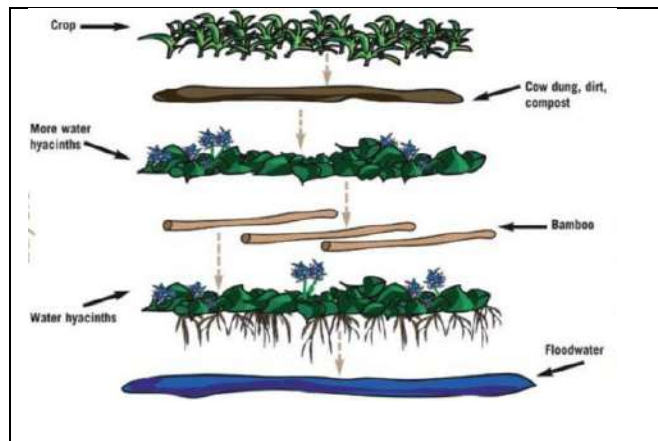




**Antony George and Jissmol Vaghese**

Waterlogged	922	20305	12.64	11495	7771
River/Stream	172	65162	40.58	61853	60338
<b>Inland Wetlands -Man-made</b>					
Reservoirs/Barrages	39	26167	16.29	24583	23421
Tanks/Ponds	439	2435	1.52	1466	530
<b>Total - Inland</b>	<b>1593</b>	<b>117122</b>	<b>72.93</b>	<b>102066</b>	<b>94595</b>
<b>Coastal Wetlands - Natural</b>					
Lagoons	39	38442	23.94	36819	35796
Creeks	19	80	0.05	77	77
Sand/Beach	111	2354	1.47	0	0
<b>Total - Coastal</b>	<b>169</b>	<b>40876</b>	<b>25.45</b>	<b>36896</b>	<b>35873</b>
<b>Sub-Total</b>	<b>1762</b>	<b>157998</b>	<b>98.39</b>	<b>138962</b>	<b>130468</b>
Wetlands (<2.25 ha), mainly Tanks	2592	2592	1.61	-	-
<b>Total</b>	<b>4354</b>	<b>160590</b>	<b>100.00</b>	<b>138962</b>	<b>130468</b>

Source: National Wetland Atlas Kerala, MoEF & CC



**Figure 1: Floating Bed Preparation**  
**Step 1 : Floating Bed Preparation**

**Figure1: Step 2 : Bed is allowed to rot for 15 – 30 days**



**Figure1: Step 3 : Seeds can be sown and transferred to raft along with Stocking the wet land with Baby Fish**

**Figure 2: Vegetables and fish are harvested**  
**Step 4 : Vegetables and fish are harvested**  
**Step 5 : Raft are broken and used as compost**





## Towards Sustainable Manufacturing: Integrating Lean Practices for Industrial Transformation

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### ABSTRACT

As industries navigate the complex landscape of global challenges, the imperative to achieve sustainable manufacturing practices has become paramount. This research article explores the synergies between lean manufacturing and Sustainable Development to propel industrial transformation towards a more environmentally conscious future. This review article provides a comprehensive examination of the current state of knowledge in lean and sustainable manufacturing and offer a nuanced understanding on the integration of lean practices as a catalyst for sustainable manufacturing. This research advocate to adopt “Sustainable Lean Manufacturing” approach in the industries and recommend government to make policies in this regard. The findings underscore the need for more researches with empirical studies to prove the capabilities of Sustainable Lean Manufacturing approach. This research serves as a valuable resource for researchers, businesses, practitioners, and policymakers for seeking to forge a path towards sustainable manufacturing by embracing lean principles and aligning their practices with global sustainability objectives.

**Keywords:** Sustainable manufacturing, Lean Manufacturing, Sustainable Development Goals (SDGs), Industrial Transformation, Sustainable Lean Manufacturing





**Syama****INTRODUCTION**

The concept of "Preserving nature for future generations" is becoming increasingly prominent today, driven by a variety of environmental concerns such as climate change, global warming, ozone depletion, and the decline of biodiversity. And discussions regarding sustainability are actively taking place. The United Nations has introduced 17 Sustainable Development Goals (SDGs) as part of the 2030 Agenda for Sustainable Development, emphasizing sustainable development as a fundamental principle for both global collaboration and national progress [13]. Nations worldwide are making concerted efforts to achieve these sustainability goals. Lean is a principle highlighting the creation of value and strives to eliminate non-value-added tasks from manufacturing processes to enhance quality and productivity, ultimately resulting in customer satisfaction [4]. Core principles of lean thinking, continuous improvement, and empowering employees serve to minimize waste and open avenues for establishing sustainable green industries [5]. Past studies indicate the feasibility of integrating Lean manufacturing, a globally acknowledged manufacturing and management philosophy with the objective of achieving sustainable development. The objective of this study is to depict the connection between two manufacturing approaches, namely sustainable and lean. This article aims to offer a comprehensive outline of the future connections between lean manufacturing and sustainable manufacturing.

**Research Methodology**

The study's goal is to explore the integration of lean manufacturing practices with the concept of sustainable manufacturing for the purpose of fostering industrial transformation. This descriptive research is conducted through a review of scholarly articles and web-based resources.

**DISCUSSION**

In light of ongoing global climate change and related environmental issues, industrial enterprises must adopt strategies and action plans facilitating a shift toward sustainable manufacturing [5]. To gain a competitive edge in terms of sustainable growth, organizations and industrial enterprises are increasingly compelled by the competitive landscape to scrutinize, restructure, and redirect their operations [5]. The imperative of transitioning to Sustainable Manufacturing is crucial at present, and industries, particularly in manufacturing, need to prioritize it as a key objective. Achieving sustainability in the manufacturing sector necessitates a comprehensive overhaul, a task that poses significant challenges. Industries, serving as the backbone of a nation, draw resources from society and reciprocate by delivering value-added products and services. They play a pivotal role in the economic and social well-being of a country, underscoring the industries' responsibility to contribute towards the welfare of future generations. Embracing sustainable manufacturing or production practices emerges as a crucial pathway to realize sustainability goals within the manufacturing sector. Lean, a renowned manufacturing paradigm originating from Japan, is a recognized stepping stone towards sustainability. Traditional lean methodologies concentrate on enhancing productivity, efficiency, revenue generation, customer value creation, and reducing various forms of waste, such as unnecessary inventory, motion, overproduction, processing, waiting, transportation, and defects [1]. In contrast, sustainable manufacturing aims to curtail the adverse environmental impacts of manufacturing operations [6]. Recognizing the synergies between Lean and environmental initiatives is widespread in the industry [12]. Combining Lean with the sustainable manufacturing paradigm positions Lean as a facilitator in achieving sustainability objectives. The core focus of Lean manufacturing is waste elimination within the production system. Throughout the production process, various forms of waste emerge, categorized under seven heads in the Lean methodology

1. Unnecessary Transportation
2. Excess Inventory
3. Unnecessary Motion
4. Over Production



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5. Over Processing
6. Wait time
7. Defects

Inefficient factory layouts, intricate material handling systems, and large batch sizes contribute to unnecessary transportation, leading to fuel wastage, air pollution, and increased costs [9]. Accumulation of inventory, including raw materials, work in process (WIP), and finished goods, ties up working capital and occupies valuable storage space, often resulting from inaccurate production planning systems. This surplus inventory may be lost due to wear and tear or damage, representing a waste of precious natural resources. Unnecessary motion occurs when employees encounter difficulties reaching production facilities, searching for materials and tools, and working in unfavourable environments. Employing ergonomic design, which creates a safe, comfortable, and efficient work environment tailored to the needs of the workers, helps minimize motion waste [14]. A well-designed ergonomic layout positively impacts quality, productivity, and the overall quality of work life for employees.

Overproduction, considered the most detrimental waste [3] leads to higher inventory carrying costs, increased storage requirements, and unnecessary human effort. Similarly, over processing, performing more than what the customer requires [2], results from inadequate demand forecasting, process non-standardization, and unclear customer specifications [9]. Waiting time or idle time arises from production bottlenecks due to machine breakdowns, long setup times, non-standardized production methods, or delays in material arrival. High idle time prolongs lead times, the time between customer order placement and product dispatch, and reducing it can save both time and costs. Defective products, not meeting customer specifications or predetermined standards, result in resource, human effort, time, and monetary wastage through defects and rework. All these wastes stem from a lack of alignment between production and market demand and inadequate production planning. Lean tools and techniques are specifically designed to mitigate or eliminate these inefficiencies in the production system. Plants operating under Lean principles are better equipped to reduce pollution and various forms of waste [12].

Combining lean practices with sustainable manufacturing yields synergistic outcomes, as advocated by previous researchers who recommend embracing "Sustainable Lean Manufacturing" instead of implementing lean and sustainable manufacturing methodologies separately. This paper endeavours to emphasize the prospects of Sustainable Lean Manufacturing within the framework of sustainable development. The global significance of sustainable development is underscored by the United Nations' Sustainable Development Goals. Sustainability extends beyond environmental conservation, encompassing social and economic dimensions. As outlined by [11], sustainability development is based on three pillars: "economic sustainability," "social sustainability," and "environmental sustainability," depicted in Figure 1. Environmental sustainability involves preserving the natural environment to sustain its productivity and resilience, supporting human life [11]. Social sustainability hinges on various factors such as the availability of robust health systems, the existence of peace and respect for human rights, equitable access to decent work, gender equality, quality education, and adherence to the rule of law [11]. Economic sustainability, on the other hand, relies on the adoption of appropriate practices in production, distribution, and consumption [11].

Industries are involved in a range of unsustainable practices that demand specific attention, including excessive resource waste and emissions during production, subpar product quality, a high incidence of defects or rejects necessitating increased reprocessing, and the generation of waste due to dissatisfaction among both customers and employees [5]. Industries contribute to environmental contamination through various means, including air emissions, wastewater discharges, improper disposal of hazardous and solid wastes, and the overuse of scarce natural resources like fuel, water, and raw materials[10]. The use of hazardous substances in the production process can have adverse effects on both human health and the environment, either directly or through their presence in products. Consequently, industries bear the responsibility for the entire product life cycle (pre-manufacturing, manufacturing, use, and post-use) and are urged to adhere to the 3Rs principle—Reduce, Reuse, and Recycle—in their operations [10].Lean positive contributes to the three pillars of sustainability [8]. The advantages of integrating lean with sustainable development are detailed in Table no. 1 below. The primary objective of implementing Lean







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manufacturing is waste reduction in the production process, contributing to both environmental and economic sustainability. The efficient utilization of resources, without unnecessary waste, aids in the conservation of precious natural resources. Addressing Lean-related wastages, such as transportation, overproduction, and over processing, supports energy and fuel conservation. Effectively managing resources, reducing waste, and conserving energy led to cost savings. Since Lean manufacturing practices are implemented at the operational or bottom level of an enterprise, successful implementation requires support and involvement from workers. Worker participation in decision-making processes related to the production process is essential for effective Lean implementation. Lean manufacturing tools like 5S, Cellular manufacturing, Jidoka (Autonomation), and visual control not only enhance the work environment but also improve the quality of work life for employees. Integrating sustainability with Lean allows industries to focus more on the well-being of both the environment and human beings.

Currently, there is considerable discourse in both academic and industrial circles about the integration of sustainability with the lean concept to bring about a transformative impact in the industrial sector, aiming to preserve nature while enhancing the overall quality of life. Research studies [4], advocate for the encouragement of the integration of lean and green practices. Sustainable manufacturing places emphasis on the development of products that are environmentally friendly across various aspects, including raw materials, manufacturing processes, and the final products, with minimal adverse environmental impacts [7]. What elevates the significance of sustainable manufacturing is its focus on the entire product life cycle, from design and development to disposal. In contrast to lean manufacturing, which primarily concentrates on manufacturing processes, sustainable manufacturing considers the entire production process right from the product's design stage. This involves designing products to be environmentally friendly, incorporating eco-friendly packaging, and avoiding the use of hazardous chemicals and materials. The production process in sustainable manufacturing employs environmentally friendly techniques, such as the use of lightweight materials, low energy consumption, and the recycling and reusing of materials [4]. It ensures optimal resource utilization without waste and pollution. Consequently, sustainable manufacturing takes into account environmental protection at every stage of production, including planning, product development, production, post-production, and disposal.

The transformation towards sustainability can significantly impact an industry's economic, social, and environmental performance, necessitating a thorough evaluation and analysis during implementation [4]. While the shift to sustainability is challenging, it offers advantages such as increased competitiveness, enhanced productivity, and improved operational efficiency. Studies emphasize that Sustainable Development requires integrated efforts at various levels, addressing social, environmental, and economic aspects [11]. The implementation of a sustainable lean approach, guided by strategic decisions, is instrumental in reducing waste in traditional manufacturing processes [1]. Numerous studies have explored the synergy between lean methodologies like Kaizen, 5S, Poka-yoke, Kanban, single-minute exchange of die, cellular manufacturing, and value stream mapping to achieve sustainability goals [1]. The Sustainable Lean Manufacturing approach aligns with Sustainable Development Goals (SDGs), offering benefits such as cost and waste reduction, long-term development, infrastructure innovation, resilience, and an improved standard of living for society[1]. Transitioning from traditional to sustainable manufacturing can enhance a company's image, fostering financial gains alongside social and environmental responsibility [10].

While existing research often focuses on individual Lean principles or environmental metrics, there is a need for studies linking Lean methodologies with all pillars of sustainability—economic, social, and environmental [12]. However, conflicting opinions exist regarding the ability of Lean methodologies alone to make an enterprise sustainable, with some researchers arguing that lean emphasizes incremental changes rather than revolutionary ones for full sustainability [4]. Empirical research is crucial to substantiate the synergistic benefits of the Sustainable Lean Manufacturing approach. The primary obstacle, high transformation costs, impedes industries from embracing such changes, necessitating policymakers to incentivize the adoption of "Sustainable Lean Manufacturing" through schemes, policies, laws, and regulations. The ongoing digital revolution, marked by advancements in Artificial Intelligence, connectivity, digitization, additive manufacturing, virtual reality, Internet of Things (IoT), machine learning, block chain, robotics, quantum computing, and synthetic biology, holds the potential to drive sustainable



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development in the years to come [13]. The emerging concept of Industry 5.0 can be seamlessly integrated with sustainability and the lean paradigm, necessitating further research in this evolving field.

**CONCLUSION**

In conclusion, the implementation of Lean practices holds the potential to significantly enhance value creation by reducing waste and increasing productivity, ultimately leading to the production of higher-quality goods and services [5]. When integrated with sustainability goals, Lean practices can bring about noteworthy transformations in the industrial sector. A review of existing literature underscores the synergies between Lean and sustainable manufacturing methodologies, emphasizing their collective impact on industrial transformation. This study has aimed to elucidate the connection between Lean and sustainability, advocating for the adoption of a "Sustainable Lean Manufacturing" methodology over individual implementations. Successful implementation of this integrated approach requires thorough planning, and governmental support through schemes, policies, laws, and regulations can further encourage its adoption. While recognizing that an immediate transformation may not be feasible, industries are urged to initiate efforts towards becoming sustainable lean enterprises.

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**Table no. 1 Lean Manufacturing and Sustainable development**

Environmental sustainability	Economical sustainability	Social sustainability
Efficient resource utilization	Cost savings through resource management	Employee development
Energy conservation	Cost savings through waste elimination	Equal opportunity
Less pollution	Cost savings through fuel conservation	Quality of work life
Waste elimination	Customer satisfaction	Health and safety
Less consumption of hazardous materials	Increased market share	Better relationship between labour and management
Reduced carbon emission	High productivity	Good working environment
Responsible production and consumption	Enhanced competitiveness	Society well being
		Social responsibility





## Perceptions and Perspectives: An In-Depth Analysis of Hospitality Professionals' Views on Women in Leadership Roles in the Hospitality Industry in Kerala

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### ABSTRACT

This study explores the participation of women in leadership positions critically in the context of the Indian hotel industry. Given the continued importance of the hospitality sector to the nation's economic expansion, it is critical to examine and resolve the gender imbalances that exist in positions of leadership. By examining the organizational, societal, and cultural variables that lead to the underrepresentation of women in high-ranking posts, the study seeks to provide insight on the causes driving these phenomena. To provide thorough insights, the research uses a mixed-methods strategy that combines qualitative and quantitative procedures. The study evaluates the attitudes, experiences, and difficulties experienced by women seeking and holding leadership positions in the Indian hospitality industry through surveys, interviews, and content analysis. The study also looks into how societal expectations, cultural norms, and organizational rules affect the career paths of women professionals in the field. The results of this study add to the corpus of knowledge by highlighting obstacles that stand in the way of women's advancement in leadership roles in the Indian hospitality industry. Through an analysis of effective case studies and activities that support gender diversity, the research seeks to provide practical suggestions for cultivating a fairer and more inclusive workplace. The analysis's conclusions may be useful to academics, policymakers, and industry stakeholders in developing measures to increase the number of women in leadership positions and support a more resilient and diversified Indian hospitality industry.

**Keywords:** Hospitality industry, Women, Leadership roles, Workplace culture, perceptions, challenges, Work force.





Sonia Thomas and Varghese Johnson

## INTRODUCTION

There is a fascinating change taking place in the ever-changing Indian hospitality industry, one that goes beyond conventional wisdom and dispels persistent misconceptions. The topic of women's participation in leadership roles in this industry is becoming increasingly important, as it reflects changing social standards and the transformative power of women in the business world. In the past, the hotel industry has been seen as mostly controlled by men, with men frequently holding senior positions. But there has been a discernible increase in the number of women shattering these stereotypes, taking on important roles, and changing the story in recent years. This is not only a symbolic change; it has significant effects on the entire performance, innovation, and culture of the industry. The purpose of this research is to examine the various facets of women's representation in leadership positions in the Indian hospitality industry. For the industry to be inclusive and successful, it is essential to comprehend the intricacies of gender representation, from the difficulties they encounter in shattering glass ceilings to the distinct viewpoints they offer. Essentially, this investigation aims to deconstruct the intricacies surrounding the representation of women in leadership roles within the Indian hospitality industry, illuminating the advancements achieved, the ongoing obstacles, and the revolutionary influence of inclusivity in molding a dynamic and progressive sector.

### Objectives

The study is undertaken

1. To access the current status of women's representation in leadership roles in the Indian hospitality industry
2. To understand the challenges faced by women aspiring to occupy leadership roles in Indian hospitality industry.
3. To study the initiatives taken by the hospitality industry to bridge the gender gap in leadership.

### Research Methodology

Primary data collected through questionnaire from 73 respondents working in hotels and academia. Secondary data was collected from journals, textbooks, AHLA reports, newspapers and magazine articles.

## RESULTS AND DISCUSSIONS

### Findings

#### Demographic Composition

The surveyed population consists of 73 respondents, with a relatively balanced gender distribution (51% male, 49% female). The majority of respondents fall within the age groups of 35-45 years (33%) and 45 years and above (27%). Educational qualifications are diverse, with 57% holding a Bachelor's degree, 36% having a Master's degree, and 7% having other qualifications. 27% of the respondents are in executive/managerial positions, 30% in middle management, and 40% in roles categorized as "Other."

#### Professional Experience

There is a diverse range of professional experience among respondents, with 53% having more than 10 years of experience. The hospitality industry sectors represented include hotels (44%), academia (40%), resorts (9%), and restaurants (7%). Majority of respondents currently working in industry with above 10 years of experience are men. Most female respondents have moved to academia after few years in the industry. Family and societal expectations and work pressures are reason behind the decline in women continuing in the industry.

#### Perceptions on Gender Diversity

A majority (53%) of respondents perceive gender diversity in the hospitality industry, while 26% do not. 21% of respondents are uncertain or have mixed feelings about the level of gender diversity in the industry. Past decade has





**Sonia Thomas and Varghese Johnson**

seen more acceptance of women in the hotel industry. Access to education, development of hospitality industry and preference of women in certain sections of the industry has prompted more women to join the industry.

**Gender-Based Discrimination**

33% of respondents reported experiencing gender-based discrimination in the workplace. A majority (53%) of respondents stated that they have not experienced gender-based discrimination. Majority of female respondents shared that they have felt gender-based discrimination, whereas most male respondents and few female respondents have negatively responded for the same. The perception of bias is not felt evenly among the respondents based on their gender.

**Challenges in Accessing Leadership Roles**

44% of respondents believe that women face challenges in accessing leadership roles in the hospitality sector. 42% disagree with this statement, suggesting a diverse range of opinions. Most female respondents felt that it is easier for men to move higher roles as they can be more flexible with their time and have less family and societal pressure.

**Representation of Women in Leadership**

The representation of women in leadership roles is perceived as moderate by the majority (53%). Varying opinions exist on whether the representation is low, high, or very high. 74% of respondents believe that there is equal opportunity for career growth for both men and women in their current organization. 10% believe there is no equal opportunity, and 16% are unsure or have mixed feelings.

**Organizational Policies and Initiatives**

44% of respondents are aware of or perceive policies and initiatives aimed at promoting gender diversity and inclusion. 56% of respondents are not aware of or do not perceive the presence of such policies and initiatives.

**Mentorship Programs**

74% of respondents are not aware of any mentorship or guidance program for women in the work place. Most organizations do not have specific mentorship or guidance for women.

**Societal and Cultural Influences**

The majority believes that societal expectations moderately influence women's career choices. Cultural norms at the workplace are perceived neutrally by 51% of respondents as factor impacting career choice of women. The number of girls joining under graduate programs in hospitality are far less than boys as the industry is still not perceived to be safe or appropriate for women.

**Effectiveness of Organizational Rules and Policies**

50% of respondents believe that organizational rules and policies are effective in promoting gender equality and supporting women's career growth. Most organizations are sensitive to the needs of safety and comfort of women but do not have programs specifically tailored to prepare women to take leadership roles.

**Measures to Improve Career Paths**

74% of respondents believe that a combination of strengthening workplace policies, fostering a more inclusive culture, and addressing societal expectations is essential to improving career paths for women professionals.

**Suggestions**

Encouraging women to hold leadership roles in the Indian hospitality industry is essential for cultivating inclusivity, diversity, and a positive work atmosphere. The following ideas are meant to uplift and assist women who hold senior positions in the Indian hospitality sector:

**Programs for Mentoring**

Create mentorship programs that place prospective female leaders in pairs with seasoned male and female leaders. This offers direction, assistance, and a forum for information sharing.







**Sonia Thomas and Varghese Johnson**

**Initiatives for Education:** Work together with academic institutions to raise awareness of the potential for women in the hospitality industry as career paths. Women seeking relevant courses and degrees should be encouraged and supported.

**Adaptable Workplace Guidelines**

Establish flexible work schedules to meet the varying demands of working women, particularly those who are also taking care of their families. This can include job-sharing plans, flexible scheduling, and remote work choices.

**Acknowledgment and Awards**

To honor and commemorate the accomplishments of female leaders in the hospitality industry, institute award and recognition schemes. Receiving public acknowledgment has the power to uplift people and foster a great workplace culture.

**Corporate Guidelines**

Examine and update company policies to make sure they support inclusivity and diversity. This covers anti-discrimination laws, family-friendly regulations, and steps to stop bias based on gender.

**Groups for Employee Resources (ERGs)**

Create ER groups devoted to women's issues in the workplace. These groups can provide a forum for candid conversations, encouragement, and support of women pursuing career progress.

**CONCLUSION**

The survey provides a comprehensive understanding of hospitality professionals' perceptions on gender-related issues in the industry. While there is a balanced gender distribution among respondents, opinions vary on gender diversity, challenges faced by women, and the effectiveness of existing policies. The findings suggest the need for continuous improvement, awareness campaigns, and a multifaceted approach to address gender-related concerns and enhance career paths for women in the hospitality sector in Kerala.

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**Data Analysis**

Representation of women in leadership roles

Representation of women in leadership roles		
Parameter	Number of Respondents	Percentage
Very Low	5	7
Low	7	10
Moderate	39	53
High	10	14
Very High	12	16





**Sonia Thomas and Varghese Johnson**

**Equal opportunities for career growth for both men and women in Hospitality Industry in India**

Hospitality industry in India provides equal opportunities for career growth for both men and women		
Parameter	Number of Respondents	Percentage
Strongly Agree	19	26
Agree	19	26
Neutral	19	26
Disagree	14	19
Strongly Disagree	2	3

**Awareness of policies or initiatives taken by organization aimed at promoting gender diversity and inclusion**

Policies and Initiatives to promote gender diversity and Inclusion		
Parameter	Number of Respondents	Percentage
Yes	15	21
No	41	56
Maybe	17	23

**Societal expectations influence the career choices of women**

Societal expectations influence the career choice for women		
Parameter	Number of Respondents	Percentage
Not at all	5	7
Slightly	12	16
Moderately	46	63
Significantly	10	14

**Cultural norms in workplace affect the career advancement of women**

Cultural norms at workplace influence career advancement of women in workplace		
Parameter	Number of Respondents	Percentage
Positively	22	30
Neutral	37	51
Negatively	7	9
Not Applicable	7	10

**Steps to improve the career paths of women professionals in the Indian hospitality sector**

Measures to improve career paths for women professionals in hospitality industry		
Parameter	Number of Respondents	Percentage
Strengthening workplace policies	12	16
Fostering a more inclusive culture	5	7
Addressing societal expectations	2	3
All of the above	54	74





**Sonia Thomas and Varghese Johnson**

<p>Fig:4.1 Perception of respondents about the representation of women in leadership roles</p>	<p>Fig 4.2: Perception of respondents about equal opportunity provided to men and women in Hospitality Industry in India.</p>
<p>Fig 4. 3: Respondents awareness about the policies and initiatives taken by the organisation</p>	<p>Fig 4.4: Perceptions of respondents about societal expectations influencing career choice for women.</p>
<p>Fig 4.5: Influence of cultural norms on career choice of women.</p>	<p>Fig 4.6: Steps suggested to improve career path of women in Indian hospitality sector</p>





## Exploration of Hybridity: An Analysis of Beauty Standards in Chimamanda Ngozi Adichie's "Americanah"

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### ABSTRACT

Hybridity is the exploration of merging of cultures in common contemporary world. The world one lives in today has cultural, linguistic and racial hybridity, which affects the life of every human being. Immigrants live a life full of contradictions, but they come under a single ideology to live a life of confutations. The woman who undergoes hybridity as a subject always tries to achieve better than a man. Migrant women experience multiple cultural hybridity. This is specially experienced by Postcolonial African women characters. Hybridity enables to create new forms of trans cultural images within the sector of patriarchy and misogyny. This paper interrogates the tortuousness of hybridity and the concept of beauty. In the novel *Americanah*, there have been proper formulations of hybridity with respect to sociopolitical freedom and a sovereignty to analyze oneself. The physical beauty of an African woman is strictly based on the beauty standards and beauty norms, laid by the white standard race. The whites believe in oppressing and under estimating the beauty of African's according to their race. The dominant group enables the immigrant group to follow the rules and accept the norms of their country. This in turn creates a low self-esteem and hatred ness among the immigrants. Those people suffer an inferiority complex as these norms and rules are unattainable by the Africans. The character suffers an identity crisis and later recovers from that, understanding cause for it. This study reveals the negative effect of cultural hybridity and beauty standards of the society.

**Keywords:** Beauty Standards, cultural hybridity, transcultural, patriarchy, misogyny.





Purnima S Kumar

## INTRODUCTION

Today's society is influenced by globalization, it has fragmented societies and cultures. This cultural influence has led to an identity crisis. An individual is often affected by individual identity crisis, which is a result of intricate merging of religion, language and societal scenario. This creates an isolated identity crisis which begins to imbricate on the other to achieve a amicable balance between individual identities and multiple identities an identity is a key element which bonds an individual to his/ her ancestral origin. This also helps the person have an individual identity or a group identity. Social civilization sprung on the key element of this foundation. Research in social science and humanities have found that globalization, peregrination and colonialism have brought in developments in cultural and movements on identities. African literature has tried to explore the diasporic life of African writers. Through their writings, the African writers were able to commemorate, their feelings untold both internal and external which subjugated their feelings of identity crisis. One can see that Novels of Adichie and Achebe portray the deft creation for arbitrary of identities. The Novel *Americanah* by Adichie transcends the readers into a trans- cultural phenomenon of modern age. African writings are more confined to African continent; it has become a commodity which is available both inside and outside Africa. The novels of Adichie explore the theme of hybridity, alienation and identity crisis. Both trans- cultural complexities and socio – political issues are exhibited in Adichie's novels.

Chimamanda Ngozi Adichie is an incipient Nigerian writer who with her exceptional writing skill has created a space for her in the Nigeria's past and present history. Her artistic ability is keenly visualized while portraying the Nigerian civil war in her *Half of a Yellow Sun* (2006). On looking keenly into her literary inquisition one can find the plight of woeful Nigerians trapped in the oppressive radicalized America in the novel *Americanah* (2013). Adichie's narrative style is similar to Chinua Achebe's novelistic opus. Achebe's artistic commitment to the socio cultural issues can be seen in the Nigerian project *A man of the people* (1966) *No longer at ease* (1960). Adichie is a transcultural writer as Achebe has a flair towards the global cultural tolerance in *Things fall Apart* (1958), Adichie portrays her global inter- cultural relationship in the novel *Americanah*. Dagnino has described trans cultural writers as "imaginative writers, who by choice or by life circumstances, experience cultural dislocation, live transnational experiences in multiple cultures/geographies/territories, expose themselves to diversity and nurture plural, flexible identities" (1). Dagnino comments that trans cultural writers, writing are in the pattern of dialogic; this dialogue can be used across cultures and beyond borders to engage in communication and also to adhere to peace and harmony. Hybridity according to Oxford English Dictionary (OED) is "A thing made by combining two different elements; a mixture." The word hybrid had its origin during the 17<sup>th</sup> century to represent off-springs of two different groups, but in the 18<sup>th</sup> century it began to describe off springs of two different culture or races. After postcolonial influence this term resulted into the relationship between colonizer and the colonized.

Their idea was to focus on the issues of the immigrants, Trans-culturalism, diasporic, and multi cultured sects. Post colonialists also focused on third space hybridity, which paved way towards cultural hybridity. This idea had been told by Homi K Bhabha in his book *The Location of Culture* (1994). Bhabha defines Hybridity is the sign of the productivity of colonial power, it's shifting forces and fixities; it is the name of the strategic reversal of the process of domination through disavowal, Hybridity is the revaluation of the assumption of colonial identity through the repetition of discriminatory identity effects. It displays the necessary deformation and displacement of all sites of discrimination and domination. (p. 112). Hybridity according to Bhabha tells the liaison between the colonizer and the colonized. All relationships are like two sides of a coin, it has understanding, independence and it also has culture in between. Culture which means culture of two different races. Homi Bhabhi addressed that both sides have a negative impact, as one analyses the power of the colonizer. *Americanah* narrates the story of a young Nigerian woman names Ifemelu who departs to America hoping of a better social and educational platform. But unfortunately, after migrating to America she had to face lot of trails and threats. She is neither able to accept the new culture or leave the reminiscence of her culture. She tries to assimilate but suffers alienation like the black sufferers in America. The discrimination created by the Americans, provokes a sense of belongingness to her mother country. Adichie here portrays the complexities and traumas suffered by the two Nigerians Ifemelu and Obinze,





**Purnima S Kumar**

who standards as a symbolic representation of diasporic life. The two characters undergo obnoxious situations when they are in love, to escape from this they shift to America and England for a better livelihood. In America Ifemelu being a well- educated and creative girl begins to write a blog about her lifestyle and also about the racial discrimination and gender consciousness faced by the black Immigrants in America. But while she came back to Nigeria her friends called her “Americanah” and annoy her as she seems to be very civilized to the standards of American culture, she seems to be an alien in Nigerian culture. “Americanah” is a novel where African diasporic experience is merged with cultural hybridity. One can easily relate the perspectives and views of two sufferers in a realistic sense. During the British reign in Africa, the indirect rule system of the British brought in various changes in the cultural practices of the African community. The British were not happy with the cultural practices of African’s and they did not agree these practices as a representation of their culture. According to Hamm, Smaandych (2005) and White (2001), is a form of cultural imperialism where one culture is dominated by another by deliberate policy or technological superiority. Due to this the African culture had to undergo a shift in their cultural scenario. The British viewed the African practices as a taboo; they assessed and evaluated the African societies’ using the criterion of the British. They also maintained an indigenous scale of evaluation for the immigrants of America, which led to a cultural shock and trauma amidst the African community. In today’s world as all human beings interact with a divergent group, it often results in the transfer of culture, which influences the cultural identity of the person. As people are exposed to too many intercultural rendezvous in the contemporary world, a person’s identity is often challenges as it faces a change or discourse. Identities according to Stuart Hall, “are a production, which is never complete, always in process, and always constituted within, not outside, representation”.

Similar merging of language and culture is evident in the life of the character Ifemelu. The character is in a plight between double -edged sword. If she talks in a Nigerian accent she will be looked down by the American’s, at the same time Nigerian’s will not assimilate her accent. Her American accent becomes a shock for the Nigerian’s and they would say “she is an American”, which may not be recognized as a compliment. Hybridity here is presented with a negative connotation as cultural and linguistic hybridity has a unique margin merging with each other. Ifemelu’s plan to drop her American accent was not accidental; as it was a conscious decision brought by the conversation with a telemarketer. It had been three years since she moved to U.S., and now she had an American accent which was complemented, for which she thanked him. “Only after she hung up did she begin to feel the stain of a burgeoning shame spreading all over her, for thinking him, for crafting his words “You sounds American” into a garland that she hung around her own neck. Why was it a compliment, an accomplishment, to sound American?” (215). One is able to acknowledge that after moving to united states she has a hybridity of American and African culture, but in this she feels she has lost her Nigerian identity. Even in the last section of the novel the first thing her Nigerian friends remarks to her upon her return is “ Americanah! Ranyinudo teased her often. ‘You are looking at things with American eyes. But the problem is that you are not even a real Americanah.

At least if you had an American accent we would tolerate your complaining!” (475-476). This she could have taken it as a pastime joke but Ifemelu grew up in Nigeria, now that she has lived in America for some time and so she feels a strange space of hybridity. She feels that she is neither in American culture nor into Nigerian, she is lost with time, though the world had a great technological development, in communication and transport there was a cultural suppression experienced by the protagonist. One can also see that Ifemelu is categorized in a cultural group that can be viewed as per global arena on the basis of her cultural traits and physical appearance. The concept of beauty is marked by the beauty standards given by the colonial ideologies that suppress or eradicate other perceptions of beauty of different cultures, especially in this novel one finds in with African culture. Philosophers and scientists ranked the race according to their evolutionary scale. The ranking was done according to Linnaeus’ taxonomy in which human beings are placed at the top as they are superior of God’s creation. Further it is sub classified according to their lineage, which is classified according to physical characteristics such as colour, facial features, hair etc. According to this classification, the Europeans were placed at the top and the African ( black people) at the bottom, more close to the species of animals, while the middle was occupied by the Asians and the red American’s. Physical and mental traits accompanied this grouping with the European described as hopeful, the dark Asiatic sad and rigid, the red American irascible and the black Negro calm and lazy (Smedley, 1999, p. 164). Linnaeus description of the





**Purnima S Kumar**

race was further substantiated by Meiners (Isaac, 2006, p. 105) who added ugliness and beauty to the black and white descriptions respectively, emphasising on the ugliness of the black people as an indicator of a deeper intellectual, moral and social primitivism and depravity thus promulgating institutionalised racism. Gobineau (1915) carries the argument on race disparity further by claiming that the white races are endowed with extraordinary energetic intelligence and a remarkable instinct for life and order (p. 207), which is unknown to the black man. In Adichie's *Americanah*, there is identity crisis which causes colour prejudices, which has seen between black and white. Racial discrimination still exists in America, which haunts the life of migrant Africans who aspire dreams to be in America. When it comes to the term 'beauty' women are the people who are affected more than men. Bartky (1990) explains that women are associated more closely with their bodies than men and are disproportionately for how they look. They are always under constant pressure to correct their bodies to conform to the ideals of feminine appearance of the time, and above all, to gain social acceptability. Thus when women engage in practices that give them the "ideal" feminine body, it is principally because an inferior status has been ascribed to that body (p. 71). Black women are shamed for their skin colour, hair and bodily appearance; they are treated as inferior and grisly. They are also judged for their intellectual and professional ability. Thus black women undergo a embarrass situation, they are unable to rescue from their original culture or are they able to align with the alien American culture.

The colour black is considered as ugly not beautiful, as per the novel. The colour black is considered as inferior and white as superior. There has always been superiority between white and black, where white race seems to be superior. Distinctions of aesthetic value, 'beautiful/ugly', have always been central to the way racism divides the world into binary oppositions in its adjudication of human worth. (Mercer 1987, 35). *Americanah* is a novel which explores the politics of beauty; it has also raced the conversations of American society. Saah (2016), offers a critique on racism in American culture, pointing out that ignorance, preconceived ideas about, and classification of a particular group of people, especially people of colour, pressures them to change their beliefs and attitudes to keep in line with the "owners" of the ideas. One can see how racial constructions of beauty affect the migrants self-esteem, and the difficulty they face to overcome it. Clark's (2013) review of the novel brings to light the different kinds of oppression, gender roles, the layers of history it takes to construct national, racial and personal identities and the idea of home. Appearance is the key element in creating identity. One can see this in the appearance of the character Ginika. In Nigeria, Ginika was seen as the most beautiful girl as she "had caramel skin and wavy hair that, when unbraided, fell down to her neck instead Afro-like" (55-56). Ginika had an appearance that resembled the beauty standards of west; she was praised by her friends for her beauty. But after she migrated to America, she was insulted by her friends for her physical appearance, she is remarked as "pork"(124). Ginika changes her appearance according to the needs of American culture. As Ifemelu notices "Ginika was much thinner, half her old size, and her head looked bigger, balanced on a long neck that brought to mind a vague, exotic animal" (122).

She notices that Ginika has lost her weight and also straightened her hair with "blond streaks shiny in the sunlight" (123). Ginika chances completely to fit into the standards of American culture, but in turn loses her identity. Ginika says to Ifemelu that she was praised for her skin colour in Nigeria but now she was mocked in America for being "half- caste", Ginika narrates her experience to Ifemelu and tells her how boys were gossiping about her because of her half- caste. She feels offended as she is biracial and half- caste. She says if someone wants to race biracial child it's better to race them in some other countries of in Nigeria. Adichie criticizes her own community of American society in a new kind of fourth category diasporic problem. Ginika also had to change her vocabulary to fit into the society. Ginika being a child belonging to upper middle class her parents were in good position but she had to face all struggles of the western society because of her physical appearance. However, unlike other characters, "Ginika had come to America with the flexibility and fluidness of youth [and] the cultural cues had shaped into her skin" (Adichie 2017, 125). Beauty as a concept is still prevalent in American society during 21<sup>st</sup> century which is well portrayed in Adichie's *Americanah*. In Joseph Conrad's *Heart of the Darkness* a defamatory image of the Africans can be seen where the physical appearance of the African race is marked as ugly and inferior. Beauty refers to hair in particular- the black hair has raised a discussion among the philosophers, sociologists and anthropologist regarding the major issue of hair. Two significant issues raised in these debates are "how hair is a significant site of meaning in societies with a history of racial discrimination, and how hair can be used to mediate the lingering effects of racial



**Purnima S Kumar**

legacy” (p. 3). Hair is designed as the feminine concept of beauty. Ifemelu meets a Senegalese hairdresser named Aisha who works in a beauty salon in Trenton, America. The novel begins by showcasing Aisha’s beauty salon and then introduces Ifemelu and her boyfriend. When Ifemelu visits Aisha’s saloon Aisha works on Ifemelu’s hair, the other women at the saloon discuss about hair – its beauty and migration. Aisha starts combing Ifemelu’s hair, she does “not understand how anybody would choose to suffer through combing natural hair, instead of simply relaxing it” (Adichie 2017, 12). Aisha being a stylist had not treated natural hair. As Black women have curled hair, and all like long straight black hair, black curled hair is treated as inferior and ugly. Aisha’s identity can be viewed as Afropolitan. One can identify third category diaspora in the character of Aisha. Aisha enquires her customer what color attachment does she require, this makes us understand her rejection for African customs. When Ifemelu responds that she wants color four, Aisha disagrees. For Aisha, that color is too black, and therefore, it looks fake (Adichie 2017, 12). Aisha easily adapts to western culture by using their cosmetics, she applies skin cream and lightens her skin tone, which later creates health problems in her.

Later Ifemelu sees that Aisha “had a skin condition, pinkish-cream whorls of discoloration on her arms and neck that looked worryingly infectious” (10). “Skin-bleaching creams, facial peels, chemical strengtheners and hot combs all aid in the cosmetic transformation of black women who struggle to attain a Euro/Western aesthetic of beauty that is unrealistic” (Walters 2014). Beauty Salons are a representation of American custom and black women adopt these Eurocentric beauty practices, in order to maintain their beauty. The women in Nigeria believe that beauty is that having “a big, firm, curvy woman, exulting in her weight and height (386), but in America size zero is valued. Therefore migrants experience a stress or pressure to change to the western ways of beauty standards. By adapting to their new beauty standards, the protagonist experiences a hybridity as a diasporic condition. Slowly one is able to recognize a change in Ifemelu, she chemically treats her hair to the western beauty standards, and she does not braid her hair, as she did in Nigeria. One day we find her looking into the mirror and running fingers through her hair, at that moment there is reclamation of identity and she recognizes her societal pressures to adapt to a new culture. This recognition compels her to stop faking American accent “a pitch of voice and a way of being that was not hers” (Adichie, 2013). She wholeheartedly returns to accept her own Nigerian heritage. Ifemelu though she is in her homeland she feels displaced between “third space” where we find her not American not African. She is able to view both the culture like an outsider. During a meeting Ifemelu is addressed as “Americanah” a term which she seen as a subsequent match to highlight her American persona.

**CONCLUSION**

Americanah is a story which echoes the life of many racialized people, these people who are forced into society’s expectation; face the deletion of the true multicultural people, who are forced to adopt the dominant culture, that is the culture of the west. But at the same time, she is unable to abandon her roots, as she embarks her new journey. But as her journey begins, she courageously adopts her new culture by creating an identity in the area of accent, her name and her hairstyle confining herself into her stereotypical environment. Today’s world belongs to immigrants with different cultural backgrounds; these immigrants are distinct from each other and also have an influence of their race. The novel portrays the long sense of identity of Ifemelu which in turn makes her return to Nigeria, where she grew up as a young girl. She had positive dreams about her life, her childhood memories made her an aspirant of high dreams. But her hybrid experience made her feel that she doesn’t belong to that modern world. Ifemelu finds it difficult to root her with an affirmative approach to her new identity; she becomes negative in her diasporic world and fails to adapt herself to the new culture. His longingness to return to her mother country and her roots show her as a representative of the postcolonial world. Adichie not only portrays as her characters intercultural encounters but also, she manifests inter culturality in everyday situation. Immigrant characters are in oscillation between two cultures, as they are not free to have a common history or ancestral background. But they try to agree with the present and create a personal identity to the new world. They gradually adapt to the new scenario, they are forced to adapt to the new culture.



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## Role of Society in Shaping Gender Roles: An Analysis of Sarat Chandra Chattopadhyay's *Srikanta* and *Devdas*

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### ABSTRACT

Women and men are affected by most societal problems, and gender equality is vital to achieving success in all sections of society. The 2030 Agenda for Sustainable Development embodies 17 sustainable goals and achieving gender equality and justice is essential to attaining all these goals. An important starting point for achieving gender equality is to revisit its representation in literature. Literature and literary characters are a representation of the reality that surrounds it. It also becomes an essential way of tracing the evolution and shaping of gender roles over time. This paper will analyse gender roles and the role of society in shaping these roles in twentieth-century Bengali literature, specifically in the noted Bengali author Sarat Chandra Chattopadhyay's eponymous novels *Srikanta* and *Devdas*. It will do this by using Simone De Beauvoir's theory of social construction of gender to show how Bengal's changing rural middle-class society, caught in the in-between ness of Western rationalism and rural traditions, shaped gender roles today. Traces of Western influences as a by-product of colonialism are still prevalent in the current society and education system. Similarly, the negotiations between Western thought and rural traditions and their influence on gender roles have also carried forward over time. This study will highlight this influence and the importance of studying such influences to achieve gender equality, specifically SDG 5, in contemporary times by revisiting gender roles in select texts by Chattopadhyay.

**Keywords:** gender equality, sustainable development, Sarat Chandra Chattopadhyay, twentieth-century, Indian literature, Bengali literature



**Jannet Johny**

## INTRODUCTION

One can trace the roots of sustainable development goals to the UN Beijing Platform for Action 1995 and the UN Millennium Development Goals 2000. Achieving gender equality is essential to attaining all UN Sustainable Development Goals 2015. Sustainable Development Goal 5 primarily focuses on ending all forms of discrimination against all women and girls everywhere, eliminating all forms of violence and harmful practices against women and children and empowering women and girls (United Nations). Multiple policies and women's groups have contributed to developing these goals over the years, and governments have continuously tried to implement these goals. Understanding gender roles and their manifestation in society is crucial to developing these policies. Most discussions surrounding Sustainable Development Goals are limited to the related social and economic policies developed for implementation. However, an essential medium for understanding gender roles is also through literature. Literature often represents the relevant social and cultural reality of its times and is crucial in explaining societal gender roles. This paper aims to focus on understanding gender roles in society through a literary analysis of twentieth-century Bengali texts and argues that this can help attain SDGs effectively.

## MATERIALS AND METHODS

In the Indian context, a reflection of significant literary development takes one back to colonial Bengal. Between the introduction of English education, the influence of the colonial masters and efforts to retain a national identity, gender roles in the society also evolved. To attain gender equality through the SDGs in contemporary times, it becomes essential to understand how this evolution has taken place and how the colonial period has shaped specific gender roles carried forward by Indian society over the years. Simone de Beauvoir famously said, "One is not born, but rather becomes, woman" (Beauvoir 330). In her book *The Second Sex*, she discusses different ways in which a child born into this world, ignorant of any categorization and biases, is made to feel superior and inferior based on their sexual organs and society's perception of their power. Beauvoir states, "Up to twelve, the girl is just as sturdy as her brother; she shows the same intellectual aptitudes; she is not barred from competing with them in any area. If well before puberty and sometimes even starting from early childhood, she already appears sexually specified, it is not because mysterious instincts immediately destine her to passivity, coquetry, or motherhood but because the intervention of others in the infant's life is almost originary, and her vocation is imperiously breathed into her from the first years of her life" (Beauvoir 330-331). A manifestation of this can be seen clearly both in society and its representation in literature. This paper will explore Beauvoir's theory of the social construction of gender by undertaking a thematic and content analysis of the works of the noted Bengali author Sarat Chandra Chattopadhyay, *Srikanta* and *Devdas*. Chattopadhyay is one of the early Indian authors who considered women an essential part of social reform and 'true independence.' It will thus attempt to understand gender roles in society and their appropriation through its strong protagonists and argue that such an analysis can pave the way for effective policies and social reform that can help attain the central goal of SDG 5, "Achieving gender equality and empowering all women and girls" (United Nations).

## RESULTS AND DISCUSSION

### Gender in Colonial Bengal

Scholars such as Gauri Viswanathan have referred to the effect of literature in shaping the culture of a particular age or group (3). Extending this, one can say that this culture also includes gender roles assigned by society. India was under the British Raj for the majority of the twentieth century. Calcutta, the capital of Bengal, was mainly the product of economic development, making it the critical link between England and India (Ghose 1255). Consequently, Bengal was an important site of both economic and literary development. Works by some of the earliest known women writers, such as Rashsundari Debi's *Amar Jiban* (My Life) and Binodini Dasi's *Amar Katha* (My Story), have brought attention to the plight of girl children and women. Debi shows that childhood for girls





**Jannet Johny**

ended traumatically, mainly with the arrival of marriage (175). Pain and intense struggles fill even the few experiences that they recall from their childhood. Girls in the nineteenth-century period and before do not seem to have an identity outside the role of a daughter, wife and mother. Similarly, Dasi's *Amar Katha* depicted how a woman's public identity, cultural ideologies, and biases were hardly separated. Their experiences differed according to the class to which they belonged. Stereotypes regarding women in theatre (such as Dasi) and the exploitation they faced are examples of the struggles they experienced. Social discrimination and the limitation of available options directed the path she followed. An in-depth analysis of her text further clarifies that her entry into this profession was not an act of free, individual choice. In the pre-Independence period, Mahatma Gandhi also focused on issues concerning women. Among his ideas concerning the issues of *Swaraj* (freedom and self-rule), empowerment of the lower strata of the social order and women, communal harmony amongst socially divided identities, and the struggle against racial discrimination offered a contrary and the most acceptable socio-political development. As Scholars Anshuman Behera and Shailesh Nayak have pointed out, he lived during the ages of "fascist leaders, communist dictators, and the colonial masters" (1).

His fights against untouchability and initiatives for women's empowerment are some of the most important contributions to social reform. His initiatives for women's empowerment are widely recognized in India (6). His efforts for women's empowerment functioned at three levels: social, political and personal. "At the personal level, Gandhi positioned women on an independent platform" (7). In the course of this, he envisioned women's independent role in society. "For Gandhi, women could play paramount roles in the society both as moral guardians and social workers, without competing with men in the sphere of power and politics" (7). He opined that any attempt by women to compete with men in power and politics would be a "reversion to barbarity" (Behra 7). He also believed in the ability of women to carry out the non-violent struggle against the social evils and British colonialism simultaneously. The fact that 'masculine' aggressive qualities dominated the world for too long, and it was time for 'feminine' qualities to come to the fore, was the basis for Gandhi's position on women's leadership in peacebuilding. He was essential in mobilising women to participate in the independence movement. The large-scale participation of women in India's freedom movement had crucial social implications in challenging and dismantling the oppressive practices that had put women in secondary positions. (7).

Scholar Jasodhara Bagchi, in her article, "Representing Nationalism: Ideology of Motherhood in Colonial Bengal," points out that "The ideology of motherhood was given an enormous importance in the cultural life of Bengal. Was the choice of the mother merely an accidental one? Or was there something about the culture of the Bengalis that created the requisite precondition for such a choice?" (65) While exploring this question, she quotes Claude Meillasoux, who states that the "great historical endeavour of man has been to reconquer the reproductive function over a woman and to fight off the incipient power derived from the latter's procreative capacities" (65). De Beauvoir points out that by denying women's reproductive power, the emancipation of women from the sphere of reproduction into the sphere of social production stands out (65). The greatness of their sons justified mothers, and loving, nurturing mothers and healthy babies were the most prized showpieces in the world of advertisements. Hence, this simultaneous privatisation and institutionalization of motherhood is described as "one of the most spectacular ploys of capitalist patriarchy" by Bagchi (65). In his expressive Bengali, Ramahansa Paramahansa complimented the mother of the religious reformer Keshab Chunder Sen. He suggested that "people will celebrate her entrails," implying that her son has glorified her womb (65). In "Beyond Bengal: Gender, Education, and the Writing of Colonial Indian History," Benjamin D. O'Dell states that when looking at Bengal in the context of colonial India, it becomes clear that three education projects emerged in the 19th century. Consequently, the projects were interrelated and changed over time. In the first project, higher education served as a means of privilege, influence, and representation for a particular group of Indian men, including the *bhadralok* class of Bengal. As part of the 19th-century reform movements, education was crucial in developing a collective sense of national identity and colonial citizenship. This group reacted to and engaged in various debates within the British Empire. In the second project, the British Raj aimed to establish a more general liberalising mission for the Indian subcontinent following the Sepoy Rebellion, which led to a more active role in India's economic and







### Jannet Johnny

social development. One area of reform was education, which focused on providing basic instruction to marginalised groups within the colonial system. This shift in responsibilities during the latter half of the 19th century challenged the traditional Brahminical caste exclusivity surrounding knowledge (536-37). During the nineteenth century, women found themselves caught between societal changes in Bengal. While some assumed that education for women was of secondary importance, it became a point of contention between different voices. This extended to the twentieth century as well. In her research on western India, Shefali Chandra notes that debates on women's education allowed English-educated men to shift gendered associations of Englishness and establish themselves at the forefront of a reconstituted normative gender hierarchy (537). Such a reconstituted hierarchy extended older forms of caste-based exclusivity into the modern era (Beauvoir 537). Scholars have offered different responses to the question "What is a woman?" as noted by Beauvoir in *The Second Sex*. Some argue that her ability to reproduce defines a woman, while others reject this notion and acknowledge that possessing a uterus does not necessarily make one a woman.

Nonetheless, it is largely agreed that females are within the human species. As stated by Beauvoir, the concept of femininity is seen as vulnerable and in danger. It is important to note that not all female human beings necessarily identify as women; they must embrace and participate in this enigmatic and vulnerable notion of femininity. Additionally, advocates of Enlightenment philosophy, rationalism, or nominalism assert that women are simply those arbitrarily designated as such among human beings (333). The world consists of individuals with different physical characteristics and interests. Although these differences may disappear in the future, they are currently evident. The definition of a woman is not solely based on her biological function but on her autonomy and freedom. Boys who desire a less harsh existence may sometimes choose femininity or homosexuality (333). Sarat Chandra Chattopadhyay, a famous Indian novelist, wrote about the social realities of rural life and familial issues in his novels. His works were relatable to a wide range of readers due to his skill in depicting the lives of the downtrodden. As Narayan Chaudhari described him, he moved "on the planes of popularity and creativity with equal facility" (p. 87) and "outreached Bankim Chandra Chattopadhyay and Rabindranath Tagore in popularity" (p. 86). A Bengal-born Indian novelist, "he was known for his artistic excellence in weaving the words to depict the life stories of the extremely downtrodden section of the society" (Ali 72). Many of Chattopadhyay's novels, such as *Bordidi* (The Elder Sister), *Palli Samaj* (The Home Coming) and *Parineeta*, deal with rural socio-economic problems, women's problems and familial issues. Meenakshi Mukherjee writes that his novel evokes "vividly and with precision a complete world rooted in the ethos of the writer's past" (61). At the novel's beginning, the milieu is a closely knit homogenous society in rural Bengal, much like Chattopadhyay's *Devdas* and *Srikanta*. It has internal inequalities and exploitations "but are bound by customs, myths, rituals, food and festivals" (61).

#### Gender in *Srikanta*

*Srikanta* was published in four serialised sections in 1917, 1918, 1927 and 1933. Govind calls this the most mature phase of Chattopadhyay's writings (p. 89). The portrayal of childhood adventures in twentieth-century Bengali fiction is very realistic. The initial three instalments of Part 1 of *Srikanta* exhibit a "regimented world of children" (89). Within this universe, the male figureheads of the household wielded the authority and subsequently passed it down to the elder siblings. The senior children supervised the younger brothers and took advantage of the powerlessness of these younger cousins. This story presents a situation where social factors influence power and control. (p. 4). As in his other novels, Gupta also points out that Saratchandra also puts women on a pedestal in *Srikanta*. From childhood onwards, I have carried the mark of shame branded on me by friends and strangers alike, so that I can no longer view my life as anything other than a prolonged stretch of ignominy. Yet, looking back, it seems to me that the cross I carry is undeserved. It seems to me that only some chosen ones are pulled by invisible strings to the centre of God's amazingly diverse creation and exposed to all its nuances. He who is thus chosen is not the proverbial *good* boy who fares well in examinations and succeeds in life. He is a compulsive rover but is not among those who travel in luxury in the company of friends...He is intelligent but impractical and eccentric. Since his passion for experience overwhelms all norms of accepted conduct he is unloved and ignored by those around him (Chattopadhyay 3). The novel, written in the first-person narrative, begins with the above passage and conveys the themes of socially accepted conduct and the consequence of not following it. In a subtle, light-hearted and



**Jannet Johny**

subversive manner, the author conveys that only 'good' boys who study well and succeed in life have a good life experience. The life of his childhood friend, Indra, is an example of this tacit nature of life. Indra is the epitome of courage for the young boy Srikanta. He, as the protagonist recalls, "aroused the wanderlust" in Srikanta (4). While Srikanta was sacred of a group of Mussalman boys who came forward to attack him and refused to eat Shiddhi leaves (seen as improper conduct), Indra stood before him, daring them to come forward and later offered Shiddhi leaves to Srikanta. He unapologetically smoked cigarettes in the open while Srikanta warned him, "If someone sees you" (5). He dared to break social rules, and the local school banned him from entering it. The protagonist, Srikanta, on the other hand, "lacks drive and ambition only in pursuit of self-seeking goals. But he acts with energy on behalf of others" (Gupta 58). He is passionate and detached, ascetic and unworldly (p. 60). These two characters, who seem to be opposites in terms of courage in their early years, also draw an image in words that explicates the conditioned young mind that is constantly conscious of social rules and acceptance. Beauvoir claims that male children are expected to excel in everything. "More is demanded of boys because of their superiority; the pride of his virility is breathed into him in order to encourage him in this difficult path" (Beauvoir 333), and the intense pressure they face concerning this manifests in the lives of these characters. This pressure on young male children exists strongly in contemporary societies as well.

Another example of similar pressure, characteristic of the colonial context of the text, is the education the characters undergo as children. Srikanta is described as a village boy sent to his aunt's house in the city to be educated. As Govind notes, *Srikanta*, among the other Saratchandra stories, highlights the extended family as the 'buffer zone' between the core family, the impoverished relatives and the world. Srikanta, a rebellious protagonist, also stayed at a relative's house for education. (p. 4-5). The novel describes the strict study routine the children were subject to in detail. A month after Srikanta's encounter with Indranath and his subsequent disappearance (hinting at Indranath's tendency to keep going on escapades), it was during a regular evening of "iron discipline" (7) that Mejda, Srikanta's second brother, that he met Indra again. The former and his cousins were doing their lessons by the light of an oil lamp. Education was given increased importance in colonial Bengal with the introduction of English education. Children were made to travel to the city, and strict discipline was enforced upon them. Mejda is referred to as preparing for the "Entrance" (7) after repeated failed attempts. The study time was strictly set between 7 pm and 9 pm. Once again, a juxtaposition of passive submissiveness to social norms is contrasted with the rebellious nature of Indra, who cuts off the small tuft of hair that hangs from the pundit's (the teacher at his school) hair. This act responded to the Sanskrit pundit's injustice in trying to make him wear a dunce cap. Children who dared to fight against what they were told to do were punished severely. As a result, Indra was forbidden from entering the school. It may be interesting to note here that no mention of girl children studying with them appears in this description of 'learning.' "That afternoon, I discovered a presence that has remained with me. It was out of this encounter, in the most impressionable years of my life, that my lifelong vision of women has been formed" (Chattopadhyay 26).

The character Annada Didi in the novel is an adequate example of Beauvoir's socially constructed women. Indra introduces her as "didi" when he tells Srikanta she will not take his money anymore, thinking he stole it from his mother's trunk (Chattopadhyay 25). She defines 'woman' in the young Srikanta's mind. According to him, "A woman is noble, chaste and loving. If there is evil surrounding her, she can, I am convinced, shed it like a worn garment at any given moment and take her place among the purest and brightest of spirits" (26). Annada Didi's characteristics and manners have, in turn, been heavily influenced by society's imposition. The qualities Srikanta lists align with the notion of 'femininity' with which females are associated in Beauvoir's discussion. It was difficult for Srikanta to believe that a woman of such grace lived in the Mussalman's house (28). Having grown up in a Brahmin household, she was educated and was conditioned to be 'noble,' 'graceful,' and 'feminine.' Apart from hinting at caste discrimination, this also points to the social conditioning that women in Brahmin households went through at the time. Further, Srikanta's shock at her having married a Mussalman indicates the expectations imposed on women about whom they should marry and what kind of families they should be associated with.



**Jannet Johny****Gender in *Devdas***

"He was delighted to see Parvati, but he didn't show any of his pleasure. He continued to smoke and solemnly said, 'Come'" (Chattopadhyay 429). The male protagonist, Devdas, is introduced as a rebellious child who does not follow instructions. In addition, he enjoys the privilege of being the zamindar's son. He enjoyed being looked after by a male servant since the age of twelve, one that very few families could afford. For most of the story, Devdas struggles to express his emotions from childhood– resulting from a possible social conditioning that he has undergone as an upper-class male. When Devdas leaves school, he is appointed a master to teach him at school. However, when Parvati leaves school, her continuing education is not considered necessary. She takes part in household chores and spends her time playing around. Her family does not see the use of her studying much. Beauvoir's notion of the pressure put on male children to take education seriously and succeed while it is not considered necessary for female children is reflected here. He is later sent to Calcutta to get access to English education. He soon starts using a walking stick and enjoys hunting more than fishing, which he enjoyed doing with Parvati in their childhood.

The influence of British education and Parvati's inability to identify with it creates a distance between the two protagonists. 'What is the point? If she can write a few letters and read a few lines of the *Ramayana* and the *Mahabharata*, it is more than enough. Your Paro is hardly likely to study law or become a barrister.' (Chattopadhyay, 433). Parvati's grandmother speaks the above lines after complaining that Govinda master (her teacher) beat her up. Devdas is shown to believe he has the authority to punish Parvati throughout the story. Parvati passively accepts her fate even when she knows she has not done anything and does not protest. Devdas committed the violence that she claimed Govinda master committed. The author repeats the words "Parvati was silent" and "Again, Parvati didn't say a word" (433) in the text. Parvati's unnecessarily apologetic behaviour towards Devdas demonstrates that society expects girl children to be passive. She makes this an excuse to avoid going to school. As Parvati becomes a teenager, she becomes shyer. Her behaviour towards Devdas reflects this. Her education is considered useless by her family, and she is married to a wealthy family and restricted to being a wife and a mother. The problem that Beauvoir arises of limiting women to their reproductive power is manifested in this example.

**CONCLUSION**

According to Suneeta Dhar, in 2015, significant progress was made towards women's rights globally. This was highlighted by new data that assessed the successes and challenges faced in implementing the UN Beijing Platform for Action and the UN Millennium Development Goals. These agreements paved the way for introducing the UN Sustainable Development Goals, highlighting areas where states have not met their gender equality obligations (48). One major challenge in attaining gender equality is the lack of understanding of the role of society in creating gender roles. Gender roles, as discussed above, have existed in society for a long time, and various socio-political-cultural factors have shaped them over the years. Gender roles have changed to a great extent in the years after the twentieth century. However, looking back at how colonial influence has affected these gender roles enables us to understand the subtle ways in which they live in society even now and how these are imposed upon children at a very young age. The pain that Parvati experiences and the struggles that Srikanta and Devdas undergo while not being able to identify with social norms make clear the difficulties experienced by children due to these imposed gender roles. Hence, a close look at literary narratives like *Devdas* and *Srikanta* and making them a part of active and academic discussions in schools and other platforms will help in sensitisation and in understanding individual experiences of gender inequality as opposed to an objective or detached account of the problem. It can thus help policymakers and society to get to the core of the issue and create effective policies to meet the sustainable development goals of gender equality.

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**Jannet Johny**

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## From Bias to Breakthrough: Traversing the Shift in Gender Stereotypes of Women in Advertisements

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### ABSTRACT

The evolution of advertisements has progressed simultaneously with societal changes. This paper aims to investigate how advertisements have changed over time in how they portray gender by analyzing gender representations in a sample of advertisements from various media channels and by identifying major stereotypes that have been perpetuated in advertising throughout the years. Further the paper aims to explore the influence of empowering and progressive advertisements on making the lives of women more sustainable. The analysis commences by examining advertisements characterized by overt gender stereotyping, progressing to an exploration of those featuring subtle gender stereotypes, and culminating in an examination of contemporary advertisements that strive to challenge traditional gender norms.

Commercials often portray stereotypical images of women and men, reinforcing traditional gender roles. This paper provides a qualitative research approach by applying George Gerber's "Cultivation Theory" to delve into how gender stereotypes in advertising affect our perceptions of ourselves and others. Additionally, it also provides an outline of the historical evolution of gender roles in advertising and the power of advertising in shaping cultural perceptions of masculinity and femininity. Advertisements may promote unrealistic beauty standards and contribute to the objectification of people, especially women. This paper also discusses the potential negative effects of advertisements on self-esteem and body image. The paper further explores the need for a critical examination of advertising practices for fostering inclusivity. It is our duty as customers to challenge these stereotypes by supporting brands that champion progressive and inclusive advertising.

**Keywords:** 5<sup>th</sup> SDG, Gender stereotypes, cultivation theory, male gaze, objectification, women in advertisements, scopophilia, superwoman, femvertising, inclusiveness.





**Jesleen Jose and Gigy Johnson**

## INTRODUCTION

Sustainability has historically been the fundamental strength of our species. The 5<sup>th</sup> Sustainable Development Goal (SDG) centres on achieving gender equality and empowering women and girls. This goal emphasizes that equal roles for women and men in families and society are essential for sustainable development, recognizing the need to provide women with equal rights and opportunities. The media has a significant impact on societal transformation. One of the primary media instruments that have the power to impact society is advertising. It also has the ability to alter people's attitudes. The issue of gender roles in ads is intricate and multidimensional, including several facets of marketing and advertising. The development of ads has kept pace with shifts in society. People's lives are greatly impacted by advertisements. George Gerbner's cultivation theory is one of the core theories of media effects. According to this theory, long term exposure to media shapes how consumers perceive the world and conduct themselves. The theory states that people who watch television frequently are more likely to be influenced by the messages from the world of television. Their worldview and perspectives begin to mirror what they see and hear on television on a regular basis. As a result, it is believed that media substantially influences how people view social reality (Perera). Certain commercials are so brilliantly done that they convince viewers to believe what they're saying and purchase the merchandise. Depending on the time period, advertising and marketing firms have developed various tactics to promote their goods. By employing popular morals to promote items, advertisements normalize undesirable societal standards under the pretext of promotions. They also delve into the subconscious of the society by trying to induce their ideas in ways that appeal to the potential consumers.

Till the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, traditional gender norms were represented in advertisements, reinforcing the idea that males should be the breadwinners and women should stay at home by reflecting conventional gender norms. Women's lack of equality and respect is not a recent development in our society. Unfortunately, the media and advertising have been major contributors to this demeaning portrayal of women for a long time. They have been subjected to continuous attacks by commercials and the hidden messages that accompany abusive character attacks. Years of sexism in the media have shaped this messaging in an effort to increase product sales. The infamous practice of toxic gender roles is one example. In advertisements of that period, women were frequently shown in home environments endorsing household goods or highlighting their caregiving responsibilities, whereas in marketing, men were depicted as powerful, affluent individuals who backed business, technology, and financial items. Gender stereotypes of men and women were employed by advertisers for marketing purposes in an attempt to make the product seem acceptable. A gender stereotype is a generalized view on the roles that are to be possessed by, or performed by, women and men ("Gender stereotyping"). The advertising industry has consistently employed stereotypical depictions of men and women so that they could easily communicate and connect with the audience.

In the 1980s, Usha featured an advertisement with the tagline, 'train' her to be the 'ideal housewife' (Bhattacharjee). This tagline is in every way problematic, as the primary focus of the ad is that all girls should be raised to be perfect housewives. It talks to the girl's parents or other authority figures, asking them to 'train' her to be the perfect housewife by purchasing their goods, even if it doesn't explicitly encourage women to buy their products (Bhattacharjee). By the late 20<sup>th</sup> century, there was a drastic change in the standards for depicting women in advertisements as the second wave of feminism challenged traditional gender roles and expectations. Advertisements began to feature women in a greater variety of jobs, including the workplace, in an effort to reflect the changing perspectives of society. Even though different companies come up with unique and innovative strategies to promote their brands, they ultimately objectify or stereotype women. Most of the commercial marketing techniques often portray women as sexualized objects or housewives that depend on a husband who is dominant and superior, thus conforming to the traditional concept of gender. Though advertisements often serve as a medium for the promotion of a particular product or service, they also end up becoming platforms that propagate unrealistic standards of beauty for women. According to media and advertisements, women with flawless skin and perfectly proportioned bodies are considered 'ideal' or 'perfect'. Advertisements associate the concept of beauty to fair complexion. They spread the misconception that people are judged and discriminated against based on the colour of





**Jesleen Jose and Gigy Johnson**

their skin. Achieving other personal objectives like marriage, empowerment, employment and self-confidence is linked to having fair skin and they portrayed women with darker skin tones as unattractive and undesirable. They also equated fair skin to success, popularity and attractiveness, thus reinforcing the notion that it is a desirable characteristic. The preference given by Indian society to fairness led to the popularity of fairness creams. Majority of marketing for fairness creams propagates the notion that having light skin or a fair complexion is now correlated with either having a good life or having the potential to attract a successful life partner. As a result, these commercials validate the biases that already exist in our culture, particularly those that are connected to gender and appearance. Furthermore, a powerful message in these ads is to simply bleach one's skin in order to overcome prejudice in society. Products like 'Fair & Lovely' promoted such unrealistic ideals of beauty. The 'Fair & Lovely' brand, which was introduced to the Indian market in 1975, was rebranded as 'Glow and Lovely' in reaction to backlash against the assumption that fair skin was the ideal for beauty (McEvoy). Even if the word 'fair' is substituted, the ads continue to instil in the minds of the viewers that light skin is the only acceptable standard of beauty. Certain advertisements diminish the value of women by focusing on their external appearance rather than their accomplishments, skills and talents, thus supporting the notion that a woman's value is related to her capacity to conform to socially acceptable beauty standards rather than her qualities.

The self-perception of a woman can be profoundly affected by these portrayals. Majority of food commercials present women as someone who is very attached to nutritious and healthy food products. Advertisements like the 'Lipton' green tea featuring Shradha Kapoor or the cereal brand 'Kellog's Be Special' by Deepika Padukone, etc. normalize stereotypes by constantly reminding a woman to be slim so that people would find them attractive. They encourage women to lose weight to fit into society's idealized version of beauty. In both advertisements, actors consume the product, which helps them reduce weight and attain a body type that is desirable (Batra). Eventually, they assert the idea that having a desirable body is a need rather than a choice. Constant portrayal of such 'idealized' images with slim bodies and smooth skin through advertisements will lead to its normalisation which manipulates more and more women to buy such products that will enhance their beauty and appearance. There are advertisements that market their products by portraying women and their bodies as commodities. Sexualizing or objectifying women is the most common method in today's advertising strategies. Feminist film theorist Laura Mulvey first used the phrase 'male gaze' in her seminal work *Visual Pleasure and Narrative Cinema* in 1975. 'Male gaze' describes how visual media such as movies and advertisements objectify women as passive objects of desire from the point of view of a heterosexual male viewer (Mulvey). Mulvey further explains 'scopophilia', which is essentially the erotic pleasure received by observing the other individual as an object of sexual arousal.

The primary objective of these ads is to increase product sales, and for that the advertisers use women as mere objects of attraction. Most of the body lotion and cream advertisements include physically attractive models to satisfy the male gaze. Products like 'Parachute' body lotion describe how using it will make a woman's skin silky and tempting, which makes her husband fall in love with her again and again (Dey). This misleading representation makes a viewer believe that women use creams and lotions just to enjoy the touch of men. The commercial basically suggests that for a woman to appear attractive to her husband, she must conform to the mainstream definition of beauty. Women are simply used as eye candy or a piece of decoration, even if their presence in the commercial is not at all relevant. Their bodies are shown as objects for others to gaze upon for visual pleasure and as a commodity that exists purely for the satisfaction of men. Even matrimonial advertisements are not an exception when it comes to the reinforcement of traditional notions of beauty, gender roles, and objectification of women. Indians' obsession with fair skin is evident in the matrimonial ads, where the skin tone of the brides and grooms is also mentioned along with their age, education, etc. In the marriage market, both men and women are treated as commodities, where their best 'qualities' or 'features' are highlighted. The ads also focus on certain words like 'handsome', 'beautiful', 'good-looking', 'reputed family', 'financially stable', 'slim', 'fair' etc., which seem to reflect the same kind of ideals of gender and beauty that are constantly given importance by society. A popular advertisement for Chavara matrimony ends with the tagline "ishtakkedukal ishtangal aayi marunnu, cherunna jeevitha pankaliye kandethumbol" means "your dislikes turn into your likes when you meet the right partner", which gives out the message that marriage is a



**Jesleen Jose and Gigy Johnson**

solution for every problem people encounter (Chavaramatrimony.com 00:00:20-00:00:25). The ad begins with a voiceover that introduces the character Sara, who is an artist but doesn't like kids, marriage, or the responsibilities associated with them. This concept of Sara changed when "Chavara Matrimony.com ilude Abiye parichayapett vivaham kazhikkunnath vare", which means "when she met Aby through Chavara matrimony.com and got married to him", and marriage helped her to conform to socially acceptable gender roles (00:00:07-00:00:11). Chavara helped her to 'transform' from a self-centered woman who wanted to escape from the societal norms of gender to a woman who enjoyed the bliss of motherhood. A woman who decides not to get married or has kids is considered 'flawed' by society, and the same ideology is re-established through this ad (Aarati). It further states that a woman's value entirely depends on her capacity to be a wife and mother. Her aspirations, dreams and desires have no space when it comes to family life. On the one hand, when certain advertisements promoted objectification and unattainable beauty standards, there were others that portrayed strong, independent women. This period saw women playing multiple roles as housewives and working employees, and hence they were referred to as 'superwoman' and 'supermom' (The Swaddle). In fact, the patriarchal culture had brainwashed them into taking responsibility for all of this. Motherhood was overly glorified to the point that she was given full responsibility for all child care tasks.

Advertisements that have the power to shape our perceptions also propagated the idea that housework is a noble, charitable, and fundamental aspect of womanhood. One common stereotype of women is that of superwomen who effortlessly handle everyday situations, stealing the stage (The Swaddle 00:00:35-00:01:04). The shifting status of women in Indian society is being emphasized and promoted by the media. The media's representation of women changed as a result of the women's liberation movement from that of the traditionally oppressive wife, mother, daughter-in-law, and housewife to that of a driven professional. This marked the dawn of the concept of 'superwoman'. Although the idea of more honourable depictions of women in the media going forward seems uplifting and positive, there are certain ambiguities in it. Such ads glorify women's unpaid work. These commercials gently inculcate the notion of the modern, idealized woman, placing tremendous strain on both working and non-working women. "Superwoman as an advertising concept primarily refers to the idea of a woman as an ultimate all-rounder—someone who not only excels in her work but also effortlessly handles household tasks", says Jean Kilbourne (Jathar). In the Airtel Smart Network advertisement, a female manager assigns duties to her staff before wrapping up and leaving for the day. She calls her husband on the way home and enquires about his supper needs. She starts taking care of the household works as soon as she gets home, making supper and making a video chat with her husband. We now realize that her spouse is one of her employees who continues to work there.

The woman is represented in this advertisement as a superwoman who is capable of simultaneously being a housewife and a boss (airtel India 00:00:00-00:01:30). The second kind is the backstage lady who quietly contributes to every man's or child's success. Many detergent advertisements, such as Surf Excel, feature a woman supporting a man or son's development and achievement. It demonstrates how women are solely responsible for performing these kinds of household duties. It is as if they are obliged to be just housewives, or it can also mean that men in the family don't have to do any of that domestic work. This is an example of 'femvertising'. It is the empowerment of women through socially-focused marketing. (The Swaddle 00:01:07-00:01:13). There are advertisements that show couples sharing home chores. The slogan 'Share the Load' ("6 Indian ads that broke gender stereotypes over the years") was coined by the detergent Ariel, and it appears in their latest ads where a kid or spouse is shown helping out. The way this is done questions and even reverses the conventional dominant roles that Indian husbands, fathers, and sons play with the women in their lives. In actuality, though, guys are simply being praised for 'helping out' with what is still considered women's labour. The sustainability of anything, be it an idea, a system, a law, or whatever, depends on how much it has been able to evolve according to changing times. Advertising and marketing agencies have also held on to this strategy for so long. There are many ads that were able to evolve and develop according to a transforming society. The diaper ads for Huggies and Pampers many years ago portrayed only moms taking care of kids. It was displayed in such a way as to get into the mind-set of the then-majority population. In contrast, recent Pampers ads have come up with really empowering taglines like "It Takes 2" and "Dads Can Change" that show that each and every father has an equal role and responsibility to play when it comes to taking



**Jesleen Jose and Gigy Johnson**

care of children and household duties. They have progressed in such a way that it shows a father who takes care of the child and who shares the same load as the wife. A very emotional ad of Pampers titled “A Father’s Promise” shows a man who has just been blessed with a baby. He promises that he will be there to take care of the baby, and the ad shows him taking care of both the child and the wife. He says that “just being called a father is not enough. I must become one” (Pampers 00:00:00-00:02:01). Such ads will eventually impact society as progressive and empowering thoughts get cultivated in the minds of men as well as young boys. As a result, they will be able to change their attitudes and take on equal responsibility. Recently, Tanishq launched a special ad campaign as a part of International Women’s Day with the question, ‘Superwoman: a compliment or an expectation?’ The objective was to disclose the truth about the challenges that women really encounter in their daily lives. The commercial film highlights how women are so focused on doing everything flawlessly and living up to the idea of multitasking that they fail to notice when it begins to take effect on them, from rising early in the morning to making breakfast to dealing with hurdles at work and home. The ad came up with the tagline, “Before she’s a superwoman, she’s a human”. According to Ranjani Krishnaswamy, General Manager-Marketing, Tanishq, women are struggling hard to maintain equilibrium between the multiple roles they play in their lives. (“Before She’s Superwoman, She’s Human”)

Advertising is an essential component of marketing. It is an effective strategy that attracts customers and makes people aware of new or existing products or services. In the present scenario, the role of advertisements goes beyond mere commercial promotion of products. They also play a role in defining perceptions of gender roles. Advertisements often propagate certain behavioural expectations of gender that shape individual perceptions. There has always been criticism and discussion regarding the representation of women in commercials. Men in advertisements are often associated with power and authority, whereas women are often shown as submissive homemakers or wives. It is surprising to discover empowering and inclusive advertisements like the Bhima Jewellery ads, which feature a transgender person, and Pamper ads with the tagline “It takes 2”. However, there still exist stereotypical and toxic ads such as Chavara Matrimony, as well as great brands like Flipkart ironically celebrating International Women’s Day by sharing messages promoting kitchen appliances. Continuous exposure to such misrepresentations and harmful stereotypes would have a profound impact on men as well as women. They have the power to shape the thought processes of the society by perpetuating stereotypical images or messages. Thus, it is crucial that advertisements appropriately represent the diversity of our society by promoting gender equality and inclusiveness. Such progressive advertisements are an asset to society as they have the power to influence people’s perspectives. They are capable of enhancing the lives of many women by reducing stress and instilling the confidence to pursue their dreams. They empower women to accept themselves as they are, recognize their rights and freedom, embrace self-love, and cultivate self-worth and independence, ultimately transforming society into a more sustainable one.

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## From Submission to Defiance: Discovering the Metaphors of Women's Long Hair and the Empowering Act of Cutting

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### ABSTRACT

Long hair on women has been a symbol of femininity and passivity throughout history, reinforcing traditional gender roles and societal conventions. However, shaving one's hair has become a potent act of defiance, challenging oppressive norms and expressing individuality. This research article explores the historical significance of women's long hair as a symbol of subjugation and societal expectations, delving into its profound symbolism. It investigates how diverse societies and cultures have used long hair to exert control over women, thereby limiting their autonomy and self-expression. The perception shift surrounding the act of removing one's hair and its transformation into an act of defiance is analysed through various historical examples. The article analyses the historical moments and cultural movements that have propelled hair cutting as a form of personal liberation, with a focus on the role of influential individuals and social movements in challenging traditional gender norms.

**Keywords:** Hair, Hair – Cutting, Power and Control, Freedom

## INTRODUCTION

Hair is perhaps one of the most complex and powerful symbols in the sociological/anthropological context. Although it is physical and therefore highly personal, under social-cultural-religious circumstances, it is public rather than private. It is the symbol whose consistency is baffling across genders, cultures, and social groups. Hair has been associated with beauty standards for women in different cultures for centuries. Hair is not just a body part but often symbolizes the person it belonged to. It brought about different psycho-social meanings to the person. "As hair is both an integral part of a woman's body and governed by external factors such as social, cultural and aesthetic conditioning, it lends itself well to the conceptualization of femininity both as a biological sex and as a socially constructed gender."(Ofek)Hair could be styled, colored, and cut to express the woman's personality and how she





**John Majel**

wanted to be seen by others. In some cases, hair could be used as a tool of resistance against societal norms and expectations. Very often, hair was treated as self, masking the identity of the person. Apart from being personal, the psycho-social identity 'hair' often plays a crucial sociological function in determining the weaker sex's identity in the power paradigm. Hair could represent power, sexuality, femininity, and vulnerability. "...historically, hair has been associated with power, and a woman's hair represented sexual power specifically".(Alexander)For women, their hair was often seen as a representation of themselves and their control over their bodies. Hair is seen as a symbol of exercising control. It becomes a visible marker of internalized control structure of the society. Externally controlled hair symbolically represents internally controlled self and existence. Hair which is a site of cultural production, a visible social marker, and a malleable cultural arte fact divides identities between the controller and the controlled. While accommodating the rules of the controller-States of patriarchy, religion- in maintaining the strictures, the controlled- women-is ordained. Hair has also been used as a symbol of control by those in power. The sign which was once a site of control can become a symbol of protest and rebellion through acts of resistance.

Hair is often seen as a symbol of control over bodies, particularly women's bodies. Hair can be used to dictate what people can and cannot do, and it can be used to control how people look and present themselves. Hair contributes to the representation of women in society by dictating how women are supposed to look and by reinforcing the idea that women must be neatly groomed and styled. Metaphoric usages of hair symbol is abundant in popular culture and literature. Abrahamic religions and some eastern religions do focus on the symbol of hair as a tool for subordinating female bodies. "Muslims, ultra-orthodox Jews, and the stricter Amish and Mennonites insist that women must cover their hair to show that they are controlled by their male relatives or their community and lack independence, particularly in relation to sexuality." (Bell et al.)Some nationalities follow a significantly stricter code of law regarding public display of hair by women, marking control of women's self expressing through the symbolism of hair. "In some countries the normative constraints placed on women are really very great: in Saudi Arabia, women cannot vote or legally operate motor vehicles; in Iran, women who dare to expose their hair or wear make-up in public can be whipped."(Yasbeck)The way in which women hair is controlled, and acted upon implies that hair is used as the medium to gain the control of individual self and the persona. The visibly controlled hair gives away the meaning of controlled body and the subjugated self. The reduction of self to a visible marker and the dead cell implies the reduction of the self to 'hair'

Elizabeth C. Hirschman in her, "Hair As Attribute, Hair As Symbol, Hair As Self" (Hirschman)reviews the social psychological, sociological and anthropological literatures to substantiate hair as an attribute of the body. She attempts at social psychology research to indicate norms surrounding the use of hair in creating and communicating gender identity. Anthony Synnott in "Shame and Glory: The Sociology of Hair"(Synnott)contends that his propositions on hair are applicable to three "zones" on each person's body: head hair, body hair and facial hair. Synnott observes that head hair is much more likely to be manipulated by women than men. The idea that hairstyle could be used to effect or signal a change in the inner self was developed further by McAlexander and Schouten in a 1989 article an "Hair Style Changes as Transition Markers"(McAlexander)Hair style is used for asserting independence from parental control, i.e., "coming of age", sexual identity formation, and shifts in social membership/affiliation. In "Hair, Sex and Dirt" P. Hershman deals with the anthropological idea of taboo in connection with hair in Sikh community. His painstaking research on Sikh migrants for the period of one year, gives a valuable insight on negating Leach's idea that hair represents phallic symbol. Hair in Punjabi ritual and social life is used to express many non-sexual values. Leach in his 1958 article 'Magical hair'(Leach)is careful to say at the beginning that he does at least know of some societies where the ritual symbolism of hair is not phallic. In his later work (Leach 1963 :38) and (Leach 1965 :174), Leach ceases to discuss hair as a phallic symbol. Edmund Leach disparages the use by psychoanalysis of ethnographic material about hair symbolism from 'primitive' societies. "Magical Hair as Dirt: Ecstatic Bodies and Postcolonial Reform in South India", (Ramberg) Lucinda Ramberg argues about the devadasi system in Yellama temple of Karnataka, wherein which lock of matted hair symbolized the presence of goddess in the body of women. It details about various reforms that were undertaken to get rid of Devadasi system, which was invariably connected with the hair. subjugating a woman to undergo hair cutting process in this context also meant that women bodies are subjugated.





**John Majel**

'Hair' which is a visible symbol of beauty becomes a social symbol of subjugation by the other. Numerous women varying from fabled tales to different eras of history reacted by relinquishing their hair on their own marking a symbolic form of renouncing the self. Freud equates this action to a sexual meaning. He Freud (1910, 32) briefly speculated that hair-cutters unwittingly 'play the part of people who carry out an act of castration on the female genital organ'; he mentions them as late as 1927 (Freud, 1927, 377). "What does the giving up of the self just by giving up the hair mean to women, and what drives them to be so need to be looked in a different context beginning with 'cutting hair' by women. It is right to posit that the weaker gender are pushed beyond a redeeming point to relinquish the very mark of their social identity. It is not just a mere form or a symbolic act of protest but a psychological drive accompanied by melancholia. The very presence of hair marks social suppression leading to melancholic death drive. The presence of hair marks the Lacanian concept of melancholy, wherein Lacan contends that it is the presence of an object rather than absence of it is the sole provider of melancholia. Freud's (Freud) explains melancholia is a result of a previously loved yet subsequently hated and internalized lost object. The triangle of loved, hated, and internalized object forms the basis for melancholic drive in individuals. But Lacan, locates melancholia mainly in the domain of psychosis. He insists on the death drive as enacted within the symbolic realm. The death drive understood not as a quasi-biological or organic force. For him death drive is the intentionality to break away from, and to destroy the network of given symbolic roles, debts, and obligations that form the basis for social existence. "The death drive defined by psychoanalyst Jacques Lacan does not describe literal death, but death within the symbolic order. After having rejected the symbolic order composed of language, conceptualization and categorization, however, the subject persists." (Dawkins). Lacan explains the state of being 'between two deaths' where in which the individual opts out of social life while endlessly thinking of actual suicide (Fink) Melancholic existence for him is the existence between 'the unreal world of social being' and 'the real world of solitude'

Russell Grigg (Clemens and Grigg) posits a counter argument to Freud stating that it is the presence of the object rather than its absence that is most fundamental in melancholia. The very presence of an object leads to melancholic feeling which feeds death drive in the symbolic realm. The very presence of hair marks the subjugation and societal condition imposed therein. Intentional breakaway from the symbolic order is performed through the act of cutting of hair, visibly marking the rejection of conceptualized social order and a deep longing for the solitude. In the fairy tale Rapunzel, the cutting of hair is used as a symbol of protest and a struggle toward freedom. Rapunzel's long hair represented her confinement and imprisonment under the tower. Cutting her hair was a symbolic act of breaking free from her captors and reclaiming her independence. The cutting of hair is symbolic in that it takes place at a time when Rapunzel comes of age, meets the prince and develops urgencies of expressing her sensuality. The long hair which otherwise kept her tamed to the orders of the enchantress, kept her away from her liberated self. It was with the chopped off hair that she embraced her new identity and went off with the prince to give expressions to her sexuality. This chopping off is also symbolic of the separation with the mother. The melancholy of being a captive and the struggle to be independent leads Rapunzel to take the extreme step of annihilation of the self by cutting her own hair. Cutting her hair is not a spontaneous act, but rather a wilful action derived from death drive.

The Mexican artist Frida Kahlo's self-portrait with her hair chopped is another case-in-point. In her self-portrait Kahlo is seen to have cast off some of her 'imposed' feminine attributes that she often used to depict herself- such as traditional embroidered Tehuana dresses or flowers in her hair- and instead sports a loose-fitting man's suit and short-clipped haircut. Her high heeled shoes in opposing directions in this portrait, her dangling earring remain, however along with her characteristic penetrating outward gaze. With locks of hair strewn across the floor, severed braid lying on her lap and on the chair, and the artist herself holding on to a pair of scissors suggest that it is she who led the action of cutting them. This combined with the lyrics of a famous Mexican song that appear at top suggest the address of a lover: "Look if I loved you, it was because of your hair. Now that you are without hair, I don't love you anymore.", (Kahlo) justly suggests her condition of her mind that she experienced after her divorce with her husband, the artist Diego Rivera, which she expresses. Here the hair makes the important point of defining a self. The hair is identified as the complete person in the absence of which the person will assume another identity altogether. The evidence of symbolic death drive is very much clear to the fact that a new identity can be forged only with the help





### John Majel

of removal of the hair on which the identity of the person is conditioned. In 2015, singer Sinead O'Connor shaved her head in public to mark International Women's Day. She wrote an open letter on her website explaining why she had chosen to do so: "I am reclaiming my body from the countless times it has been abused by institutions or people who thought they owned me." (Phil) "I didn't want to be raped, I didn't want to be molested." (Phil) The melancholic death drive is very much evident in the fact that a mere desire to exist as a commoner is much more important than being myself and be traumatised by having hair as an identity. Similarly, when actress Demi Moore famously chopped off all of her long locks in the movie *G.I. Jane* (Scott), she was sending a powerful message of women's empowerment. Moore portrayed a strong female character who was determined to break down gender stereotypes and prove her worth in the military despite facing extreme adversity. She conveys a powerful message that to be identified as an equal being, she has to give up what defines her as a woman. In the contemporary lens, the Iranian women's protest in September, 2022, (Kianpour) symbolically shows how the presence of an object, rather than the absence of it, leads to melancholia and to symbolic death drive in women. Masha Amini's case of improper wearing of the headscarf, 'displaying' hair, had led to her arrest by the moral police, from which she could not return alive. Women who protested against the Moral police of Iran, cut their hair off in public to showcase their drive towards freedom, hair here represents subjugation and repressiveness. So, the expression that the moral police wish to suppress has to do with one's expression of one's being, one's self, one's identity that includes their sensuality.

Therefore it is natural that women find some means to get out of it when the physical part of the body can symbolise the whole self. The liberation of the self would mean assuming the self without subjugating part. The cutting of hair is therefore more than just an aesthetic choice; it can be seen as an act of liberation and resistance for women around the world. By shaving their heads, women are able to reclaim autonomy and agency over their own lives. Hair, thus, is understood as the social marker of the controller on the controlled. And the chopping of the same symbolizes the controlled subject's taking back of the power from the controller. Bringing the conception of melancholia and identity formation solely to the spectrum of female heterosexuality which in the heterosexual spectrum itself forms the other, would lead to bifurcating the identity into two- one, the constructed female identity by the controller- masculine, society- through social symbols like kempt, covered hair. And, two, the 'self' of the female that forms the radical other in this case; where the first category- the constructed identity- is purchased through a melancholic incorporation of the other 'self' of the female that it disavows. This identity of the radical other 'self' which keeps the constructed identity alive by a melancholic incorporation is gained back by regaining the control, which in case of hair as the social marker, is by chopping it off, which helps the 'self' to gain back the control and power over one's self, thus, getting rid of the melancholic identity which is otherwise embraced to celebrate the subjective controller. Thus, by doing this, women are ridding themselves off their melancholic identities which they had embraced so far, by eradicating their radical otherness, which is what they are revolting against, in a deeper understanding. This act that they are shredding off their pitiful 'melancholia' through symbolic death is what might prepare a path for the new feminisms to come.

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## Can Biospheric Values and Local Environmental Concern Shape Private Sphere Behaviors Towards Sustainable Living?

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### ABSTRACT

This study explores the link between bio spheric values, local environmental concern, and private sphere behavior among the youth demographic within Itanagar Smart City, Arunachal Pradesh. As environmental awareness gains prominence in today's world, understanding the factors that drive individuals to engage in sustainable practices becomes crucial. By focusing on the youth, who are pivotal in shaping the city's future, the study aims to unravel the intricate dynamics that influence eco-conscious behaviors within the private sphere. Through a targeted sampling approach and a combination of qualitative and quantitative methods, the research aims to provide insights into how personal values and local environmental concerns intersect, driving proactive actions that contribute to a greener urban landscape. The study was conducted in Itanagar smart city using stratified random sampling with 189 respondents. SEM was employed to test the hypothesis. The study result shows that both bio spheric value and local environment concern has a positive impact on private sphere behavior of the youth population in the study area. The outcome of the study has an implication for authorities such as smart city development corporation, forest corporation and general administration for policy making.

**Keywords:** Biospheric values, Local environment concern, Private sphere behavior, Itanagar smart city



**Mudang Tagiya and Odang Mara****INTRODUCTION**

In an age marked by increasing environmental concerns and a persistent call for sustainable practices, there has been an unparalleled emphasis on the role of individual behaviors in shaping our common ecological future. As societies grapple with pressing environmental challenges, the exploration of factors driving greener behaviors at the local level has become a critical endeavor (Steg & Vlek, 2009). In light of the continually environmental concerns, the concept of "green behavior" has emerged as a crucial aspect of modern society, responding to the growing environmental challenges that the world faces. It promotes minimization of negative impacts on the environment and promote sustainability (Gifford & Nilsson, 2014). "Green behavior" are actions that contribute to the betterment of the environment or mitigate harm to it(Steg & Vlek, 2009)such as water and energy conservations, recycling, avoiding the use of disposable products(Han *et al.*, 2018). It is also known as pro-environmental behavior (Krajhanzl, 2010). According to Stern (2000)pro-environmental behavior comprises of four dimensions i.e., private-sphere environmentalism and other environmentally significant behaviors, non-activist behaviors in the public sphere, environmental activism. According to various studies, values have been identified as an antecedent of pro environmental behaviors (Steg *et al.*, 2015). These values include biospheric values, altruistic values, egoistic values and hedonic values (Steg and Groot, 2012). Research has demonstrated that biospheric values, in particular, exhibit a strong and consistent correlation with environmental preferences, intentions, and behaviors. (Steg and Groot, 2012).

Pro-environmental behavior is closely connected to environmental concerns because it's how people show they care about the environment in real life (Xu *et al.*, 2021). Environmental concerns arise from an individual's awareness of issues like climate change, pollution, and resource depletion. This awareness fosters a sense of responsibility and worry about the planet's future, prompting pro-environmental behavior. Northeast India, a captivating region nestled in the eastern region of the country, known for its diverse cultures, pristine landscapes, beauty and remarkable biodiversity. Comprising eight states, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. Nestled within the unique environmental landscape of Northeast India lies Arunachal Pradesh, popularly known as the "Land of the Rising Sun." Itanagar smart city is the capital of the state. However, the recent time, waste management challenges facing by the Itanagar smart city initiatives highlight the complexity of the environmental issues at hand. These challenges encompass littering, improper waste disposal, and a deficiency in recycling facilities, collectively contributing to the degradation of the local environment.

Of even greater concern is the uncontrolled dumping of waste into streams and rivers, posing a severe ecological threat and directly compromising water quality. This unchecked pollution also infiltrates the underground water, leading to contamination and a subsequent decline in water levels. The gravity of the issue is evidenced by the disposal of non-biodegradable waste through burning or haphazard dumping into nearby waterways, further perpetuating the environmental crisis (EastMojo, 2023; Arunachal Times, 2021). Furthermore, Itanagar ranked seventh among the ten dirtiest cities in the country in the category of those with a population below 10 lakhs in the Swachh Survekshan 2020 and 5<sup>th</sup> in 2023. In light of these persistent challenges, this study aims to investigate the intricate relationship between biospheric values, environmental concern, and private sphere behavior within the youth demographic of Itanagar's smart city. By exploring into these aspects, the study seeks to unravel the motivations and factors that drive eco-conscious actions, contributing to a complete understanding of the interrelationship among individual values, environmental awareness, and behavioral responses. The study incorporates Schwartz's value theory to examine the subsequent environmental belief, outlooks, social norms, intentions, and, ultimately, pro-environmental behaviors.

**Research question**

In light of the growing significance of individual behaviors in addressing pressing environmental challenges and the unique environmental context of Itanagar, this study seeks to answer the following research questions:

1. To what extent do bio spheric values influence private sphere pro-environmental behavior among youths in Itanagar, Arunachal Pradesh?





**Mudang Tagiya and Odang Mara**

2. How do biospheric values, environmental concern, and private sphere behavior relate to each other within the context of a smart city like Itanagar?
3. Do the pressing environmental challenges faced by Itanagar's smart city initiatives influence the pro-environmental behavior of its youth population?

**Literature Review and Hypotheses Development****Schwartz's Value Theory**

"According to this theory, individuals hold a set of core values that guide their attitudes, decisions, and behaviors. These values are organized into ten motivational types, including Universalism, Benevolence, and Self-Direction (Schwartz, 1992, pp. 10-12)." Studies shows that there is a strong connection between values defined by Schwartz's and pro-environmental behavior.

**Biospheric Value**

Biospheric values, as defined by Schultz (2001), are a type of environmental value orientation characterized by a deep and intrinsic appreciation for nature and the environment. People having strong biospheric values believe in the intrinsic worth of the natural world and have a genuine concern for the well-being of the environment and its ecosystems.

**Environmental Concerns**

Environmental concern refers to an individual's or a society's level of care, interest, and awareness regarding environmental issues, including ecological sustainability, conservation, and the well-being of the natural world (Dunlap *et al.*, 2000). According to Kim *et al.* (2019), environmental concern refers to the evaluation of one's own or others' actions in terms of their impact on the environment. The definition given by authors Fransson and Garling (1999) on environmental concern as "specific attitude toward environmentally relevant behavior within a broader value orientation".

**Private Sphere Behavior**

Private-sphere behaviors are actions that people take in the real world to safeguard the environment by investing their own time and energy in it (Stern, 2000; Rice, 2006). These actions have a direct impact on the environment's quality. Private sector conduct is a subset of pro-environmental behavior that places an emphasis on practical acts that directly benefit the environment (Rice, 2006), such as eco-friendly household practices, daily routines, and consumption decisions.

**Biospheric Value And Its Relation With Private Sphere Behavior**

Environmental preferences, intentions, and behavior are all substantially and consistently correlated with biospheric values, according to studies (Steg & De Groot, 2012). People with high biospheric values tend to exhibit pro-environmental choices as well as to act in a pro-environmental manner. People who firmly believe in biospheric values are concerned with nature and the environment, and they place a greater emphasis on the effects of their activities on the natural world. It has been demonstrated that a variety of pro-environmental attitudes and behaviors, such as acceptance of climate change policies (Steg *et al.*, 2011), are correlated with 'biospheric values', 'sustainable consumption' (Thøgersen & Ölander, 2002), 'environmental activism' (Steg *et al.*, 2011), 'private-sphere behaviour' (Schultz & Zelezny, 1998), 'preference for restaurants serving organic food' (Steg *et al.*, 2012), and 'donating money to an environmental rather than a humanitarian organization' (De Groot & Steg, 2008). Therefore, based on the context provided above, the researcher has formulated the following hypotheses. H1: Biospheric values have a significant positive impact on private sphere behavior







### Mudang Tagiya and Odang Mara

#### Environmental Concerns and its Relation with Private Sphere Behavior

Empirical evidence supports the notion that individuals having environmental concern are inclined to exhibit responsible behavior (Oreg and Katz-Gerro, 2006). People who exhibit concern for environment are always make personal sacrifices for environmental preservation, thereby fostering pro-environmental (private sphere) behaviors within their sphere of influence (Oreg and Katz-Gerro, 2006). According to Xiao and Dunlap (2007) and Xiao and McCright (2007), individual environmental perceptions could differ due to variations in topography. In light of the established importance of environmental concern in influencing pro-environmental behaviors, the following hypothesis has been formulated. H2: Local environment concern has a significant positive impact on private sphere behavior.

## RESEARCH METHODOLOGY

#### Research Instrument

In this study, the scale's items were adapted from literature; however, small modification was done to make it understandable for respondents. Four items measuring private sphere behavior was adapted from the study by Greenspan *et al.* 2012 and McDougale *et al.* 2015. Four items adopted from De Groot and Steg 2007 and Katz-Gerro *et al.* 2017 were used to measure biospheric value, while environmental concern using the nine items proposed by Diekmann and Preisendörfer (2003). All of these measurement items used were in 5-point Likert scale.

#### Sample Design and Data Collections

A survey was conducted in the month of August 2023, using question nairea among the youths age between 14 – 24 years residing in the smart city Itanagar, Arunachal Pradesh, India. Stratified random sampling was adopted for this present study. The questionnaire included 17-items to measure the variables as shown in table-1. According to Hair *et al.*, (2010), questionnaire items and sample ratio should be 1:10 i.e., for each item there should be 10 respondents ( $n \times 10$ ) which makes it 170 respondents. However, for more robust outcome, 250 copies of the questionnaire were distributed. After excluding the incomplete responses, a final set of 189 complete questionnaires was remained, representing a response rate of 78%.

#### Analysis of Data

SPSS version 21.0 was employed to conduct data analysis. Reliability analysis and internal consistency of the constructs was performed before testing hypothesis. According to Anderson and Gerbing (1988), the measurement scales were then subjected to scrutiny to confirm their convergent and discriminant validity. Confirmatory factor analysis (CFA) was used to establish composite reliability. Subsequently, structural equation modeling (SEM) was conducted using AMOS (Analysis of Moment Structure) software to validate the relationships among biospheric value, environmental concern, and private sphere behavior.

## RESULTS

#### Demographic Profile of the Respondents

Table 1, highlights the demographic profile of the respondents. Table shows that 59.3% of the respondents were male and 40.7% were female. The age distribution indicates that the respondents span a range of age groups, with the highest proportion (23.8%) falling between the ages of 22 and 24. In terms of education, the respondents have diverse educational backgrounds, with the highest percentage (31.2%) having completed graduation. The education levels of the respondents' parents also vary, with the most common category being "No formal education" at 30.7%.

#### Measurement Model

The measurement model comprises three variables: biospheric value, local environmental concern, and private sphere behavior. To assess the reliability and validity of these constructs, Confirmatory Factor Analysis (CFA) was employed using the Maximum Likelihood Estimation (MLE) method. As per Hair *et al.* (2015), a commonly accepted





### Mudang Tagiya and Odang Mara

threshold for Average Variance Extracted (AVE) is 0.5 or higher and for construct reliability (CR) stands at 0.7 or higher. Additionally, factor loadings within the range of 0.6 to 0.7 may be considered acceptable, provided that other indicators of construct validity are favorable. Hence, the items having factor loading above 0.6 was considered for the study and the rest of the items were removed. However, the item LE-6 measuring the construct environmental concern was 0.59 and was retain as AVE of the construct was above threshold value Hair *et al.* (2015). The total items remain left after removing were 15 items. Table 2 highlights the factor loading and reliability of the construct after CFA. From the CFA result, the factor loadings were found to be satisfactory, indicating that the measurement model exhibited good model fitness. The results of the factor analysis revealed that the factors exhibited adequate values for GFI (goodness-of-fit index: 0.9 or higher), AGFI (adjusted goodness-of-fit index: 0.9 or higher), RMSR (root mean square residual: 0.05 or lower), and p-value (0.05 or higher), thus confirming their convergent validity. The discriminant validity also accessed using Fornell-Larker criterion as shown in Table 3. The square of AVE values for each construct are highlighted in bold, while the remaining values represent the squared correlation coefficients between the constructs. The findings show that obtained AVE values are greater than squared correlation coefficients, demonstrating that construct variance was more pronounced than the shared variance between constructs. Overall, these findings provided sufficient evidence in supporting the discriminant validity of the measures (Hair *et al.*, 2006).

#### Structural Model

Figure 1 displays the ultimate structural model estimation, while Table 4 provides the standardized path coefficients derived from the assessment of the proposed structural model. Importantly, all of the structural path estimates were found to be statistically significant ( $p < 0.05$ ). The anticipated association between biospheric values and private sphere behavior was corroborated by the corresponding coefficient of 0.82 ( $p < 0.05$ ). These findings suggest that individuals with elevated biospheric values are more inclined to exhibit increased private sphere behavior. i.e., pro-environment behavior, which supports **H1**. The proposed relationship between the environmental concerns and private sphere behavior was supported by the associated estimate of 0.45 ( $p < .05$ ). These findings signify that young individuals with heightened environmental concerns are more prone to engage in private sphere behavior, thus providing support for **H2**.

## FINDINGS AND DISCUSSION

This study has attempted to understand pro-environment behavior (private sphere behavior) among youths in the smart city Itanagar of Arunachal Pradesh, through the environmental concern and biospheric values. Structural equation modeling was employed to evaluate the hypotheses formulated in this study, and the results supported both H1 and H2. Environmental concern exhibited a substantial influence on private sphere behavior, aligning with prior research that has highlighted the role of environmental concern in shaping private sphere behavior (Zibenberg *et al.*, 2018; Liobikienė & Poškus, 2019). Furthermore, the study found a significant relationship between biospheric values and private sphere behavior, affirming the significance of these variables as predictors of private sphere behavior, consistent with previous literature (Gkargkavouzi *et al.*, 2019; Wu & Zhu, 2021; Uddin *et al.*, 2021) Finally, as discussed, both biospheric values and environmental concern influences private sphere behavior. Awareness programs could be designed to emphasize and promote biospheric values among youth. These initiatives could be integrated into school curricula, community workshops, or online platforms, fostering an understanding of the intrinsic connection between personal values and pro-environmental actions. Educational initiatives could be tailored to emphasize the significance of environmental issues. Environmental education programs could highlight the impact of personal behaviors on the environment, motivating individuals to engage in pro-environmental actions within their personal sphere.

#### Theoretical and practical implication

This study contributes to the theoretical understanding of the factors influencing pro-environmental behavior among youths in the Itanagar smart city contexts. The study provides empirical validation of existing theories that posit a





### Mudang Tagiya and Odang Mara

relationship between biospheric values, environmental concern, and pro-environmental behavior. Practically, the study highlights the significance of targeted educational initiatives. The results suggest that awareness programs should be developed to emphasize and promote biospheric values among the youth population. These initiatives, whether integrated into school curricula, community workshops, or online platforms, can foster a deep understanding of the intrinsic connection between personal values and pro-environmental actions. Moreover, the study emphasizes the potential for community engagement in promoting pro-environmental behavior. The environmental awareness and actions can be encouraged at the community level. By creating projects and activities that make individuals feel responsible for their local environment, the effectiveness of individual pro-environmental actions can be amplified. Encouraging collective responsibility and community-based initiatives can result in a more significant and lasting impact on local environmental conservation efforts. In addition to that, the policymakers and local authorities can draw insights from this study to design and implement policies that align with citizens' environmental concerns and promote sustainable actions within the private sphere.

#### Limitations and future research

The current study has certain limitations. The sample size was 189 respondents only, a larger and more diverse sample could enhance the study's generalizability. The data collection was conducted within a single month, potentially overlooking seasonal variations in respondents' behaviors and attitudes. Also, the study was conducted in smart city of Itanagar, hence the result may not be generalized and applicable to other smart cities of India. Also, the study relied on adapted measurement items from previous research, which may introduce context-specific biases. Future research could explore methods to minimize and assess non-sampling error to further enhance the validity of findings. Similar studies may be conducted in different geographical region and smart cities to check the result and its variation. Cross-cultural comparisons across various smart cities or cultural contexts could uncover unique patterns and solutions. This study was conducted using two independent variables; hence this study may be extended by incorporating different variable such as self-direction, environmental ethics, environmental preferences, environmental self-identity and so on.

## CONCLUSIONS

In conclusion, this research provides valuable insights into the factors influencing pro-environmental behavior among youth in the smart city of Itanagar, Arunachal Pradesh, India. It was found that both biospheric values and environmental concern significantly impact private sphere behavior, confirming the hypotheses. This highlights the important role of these variables in motivating environmentally conscious actions among young, individuals and societies in the study area. In summary, this study significantly contributes to the field of environmental psychology and offers valuable insights for sustainable urban development in smart cities.

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**Table no. 1. Demographic profile of the respondents**

Variables	Category	Frequency (N=189)	Percentage (%)
Gender	Male	112	59.3
	Female	77	40.7
Age (in years)	14 – 16	32	16.9
	16 – 18	41	21.7
	18 – 20	33	17.5
	20 – 22	38	20.1
	22 – 24	45	23.8
Education	Elementary	36	19.0
	Higher Secondary	49	25.9
	Diploma	6	3.2
	Graduation	59	31.2
	Post Graduation	39	20.6
Parent's education	No formal education	58	30.7
	Up to primary	38	20.1
	Elementary	33	17.5
	Higher secondary	9	4.76
	Graduation	35	18.5
	Post Graduation	16	8.5

**Table 2: Measurement properties of variables.**

Variables	Items	Factor loading	AVE	CR	$\alpha$
Biospheric value	BV-3	0.85	0.71	0.71	0.82
	BV-4	0.83			
Environmental concern	LE-1	0.74	0.50	0.85	0.89
	LE-2	0.69			
	LE-3	0.76			
	LE-4	0.72			
	LE-5	0.82			
	LE-6	0.59			
	LE-7	0.69			
	LE-8	0.61			
	LE-9	0.63			
Private sphere behavior	PSB-1	0.79	0.55	0.86	0.85
	PSB-2	0.73			
	PSB-3	0.81			
	PSB-4	0.76			







**Mudang Tagiya and Odang Mara**

**Table 3 Discriminant validity**

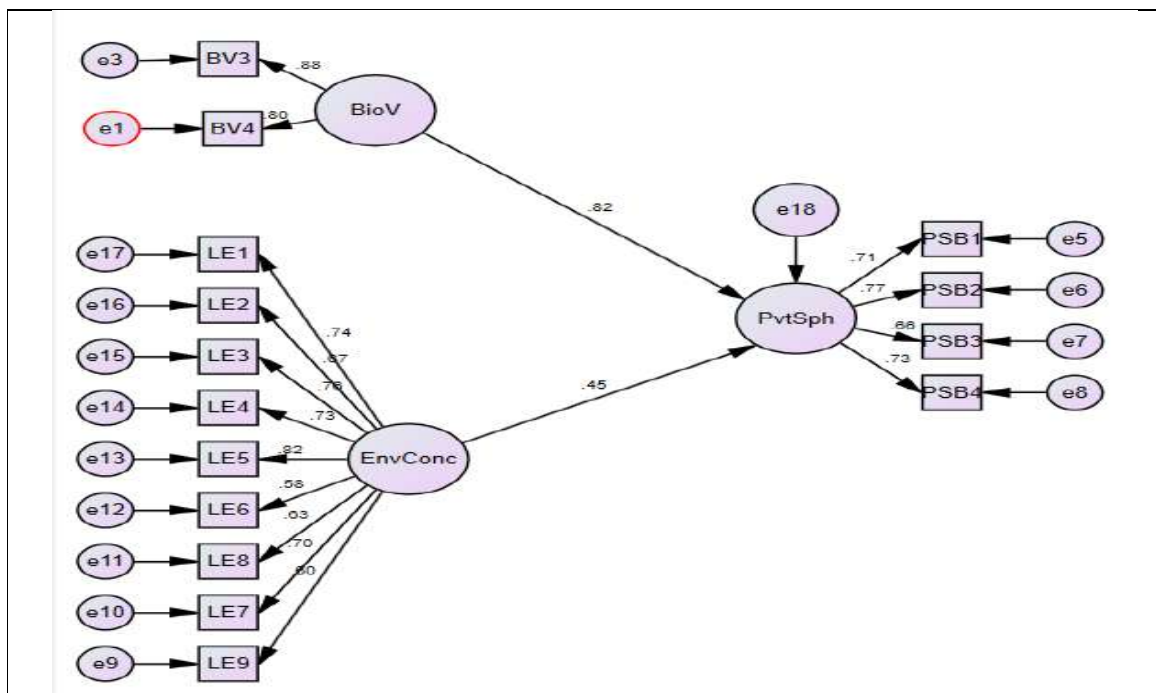
	Biospheric value	Private sphere behavior	Environmental concern
Biospheric value	<b>0.84</b>		
Private sphere behavior	.721	<b>0.74</b>	
Environmental concern	.605	.704	<b>0.71</b>

$\chi^2 = 287.54$  (p = 0.00), df = 96,  $\chi^2/df = 2.98$ , GFI = 0.903, AGFI = 0.895, NFI = 0.91, CFI = 0.95, RMSEA = 0.076.

**Table 4 Results of hypothesis testing**

Hypothesis	Path coefficients	CR value	p-value	Result
<b>H1:</b> Biospheric value → Private sphere behavior	0.82	8.95	0.000**	Supported
<b>H2:</b> Environmental concern → Private sphere behavior	0.45	5.87	0.000**	Supported

$\chi^2/df = 2.92$ ; GFI = 0.926; AGFI = 0.90; RMSR = 0.055; p-value = 0.00  
\*\*p < 0.05



**Figure no.2 Path model**







## Beyond Stereotypes: Unraveling Cognitive Diversity in Contemporary Literature's Gender Narratives

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### ABSTRACT

This research explores the nuanced portrayal of gender-based cognitive differences in literature using feminist literary theory. It critically analyzes how literature reflects and challenges traditional gender roles, illuminating power dynamics and societal expectations shaping characters' cognitive experiences. Despite average cognitive differences between genders, individual variations are substantial, cautioning against misleading stereotypes. Historical literature often perpetuated gender norms, depicting men as logical and women as emotional. However, contemporary literature increasingly breaks these stereotypes, presenting characters with diverse cognitive abilities regardless of gender. This study, employing a multifaceted theoretical approach, unravels the intricate layers of cognitive representations in literature, acknowledging the dynamic interplay between societal influences, individual experiences, and diverse theoretical perspectives. It contributes to a deeper understanding of how literature shapes perceptions of gender-based cognitive differences, offering insights into the evolving landscape of gender representation in literary works.

**Keywords:** Stereotypes, Cognitive Diversity, Gender Narratives, Feminism, Postcolonial Theory, Narrative Theory

### INTRODUCTION

This research paper intricately examines the portrayal of cognitive differences between genders in literature, employing a diverse array of theoretical frameworks. Through the lens of feminist literary theory, it critically





### Zayana

assesses how literature both reflects and challenges conventional gender roles, unraveling power dynamics and societal expectations that mold characters' cognitive experiences. While acknowledging average cognitive differences between genders, the study emphasizes the substantial individual variations and cautions against misleading stereotypes. Historically, literature often mirrored and reinforced societal norms regarding cognitive disparities, depicting men as logical thinkers and women as emotionally intuitive. Yet, as societal attitudes evolved, so did literary representations. Modern works increasingly defy these stereotypes, presenting characters with varied cognitive abilities regardless of gender. Literature now serves as a platform for critiquing traditional gender roles, fostering a more inclusive and accurate portrayal of cognitive diversity. Utilizing a multifaceted theoretical approach, the research delves into the intricate layers of cognitive representations in literature. It recognizes the dynamic interplay between societal influences, individual experiences, and diverse theoretical perspectives. Cultural theories rooted in feminist literary theory, postcolonial theory, and narrative theory offer analytical frameworks for understanding the multifaceted dimensions of literature, enriching the exploration of gender and cognition. The study has dual objectives: firstly, to explore the contributions of cultural theories to understanding cognitive representations in literature; and secondly, to conduct a detailed analysis of contemporary literary works and movies, employing these cultural lenses to unveil the complex ways characters' cognitive landscapes are shaped by broader cultural attitudes. By achieving these objectives, the research contributes to a nuanced understanding of how literature reflects and shapes perceptions of cognitive differences between genders, shedding light on the evolving landscape of gender representation in literary works.

#### Cultural Theories and Cognitive Representation

##### Feminist Literary Theory: Interrogating Traditional Gender Roles

Cultural theories provide a comprehensive framework for dissecting cognitive representations in literature, with feminist literary theory at the forefront. This foundational lens seeks to dismantle entrenched gender roles in literature, unveiling the power dynamics inherent in societal expectations. In Chimamanda Ngozi Adichie's 'Americanah,' the narrative challenges traditional gender norms, offering a contemporary exploration within the framework of feminist literary theory. The film adaptation of Gillian Flynn's 'Gone Girl' further delves into power dynamics, illustrating the consequences of conformity or resistance to established norms.

##### Postcolonial Theory: Cross-Cultural Perspectives on Gender Roles

Postcolonial theory extends the analysis by offering cross-cultural perspectives on gender roles, rooted in the aftermath of colonial histories. Arundhati Roy's 'The Ministry of Utmost Happiness' serves as a contemporary example, intricately weaving postcolonial perspectives into the narrative. The novel explores gender roles within the broader context of India's postcolonial history. The film 'Belle' directed by Amma Asante provides cross-cultural insights into gender, race, and power dynamics during the colonial era.

##### Narrative Theory: Deconstructing Storytelling Elements

Narrative theory emerges as a crucial lens for understanding the impact of storytelling elements on cognitive experiences. Salman Rushdie's 'Midnight's Children' showcases narrative complexity, unraveling layers of characters' cognitive landscapes. The film 'Eternal Sunshine of the Spotless Mind' employs inventive storytelling techniques to convey characters grappling with memory and identity.

##### Synthesis: Cultural Influences on Cognitive Representations

Synthesizing findings from feminist literary theory, postcolonial theory, and narrative theory reveals common themes and distinctive perspectives in cultural influences on cognitive representations. While feminist theory challenges gender norms, postcolonial theory adds cross-cultural understanding, and narrative theory emphasizes storytelling's role in shaping cognition. Case studies further illuminate the interplay of these theories, allowing a nuanced exploration of the complexities inherent in cultural influences on cognitive representations in literature. Examining specific characters and narratives enhances our understanding of the intricate ways cultural theories shape characters' cognitive experiences.





### Zayana

#### **Embracing Diversity: Contemporary Literature's Expansive Exploration of Gender Narratives**

In the dynamic landscape of contemporary literature, a profound transformation is underway, ushering in a new era of inclusivity and diversity in gender narratives. This comprehensive exploration delves into various facets contributing to the deconstruction of traditional gender roles, fostering a more nuanced understanding of identity. From the deconstruction of traditional roles to the exploration of mental health, diverse narrative perspectives, global perspectives, the evolution of language, and the critique of stereotypes, contemporary literature is actively engaging with and unraveling the complexities of gender cognitive variations.

#### **Deconstruction of Traditional Roles**

Contemporary authors courageously deconstruct traditional gender roles, challenging societal expectations. Virginia Woolf's "Orlando" and Charlotte Perkins Gilman's "The Yellow Wallpaper" offer poignant portrayals of characters confined by patriarchal expectations, serving as metaphors for the oppressive nature of traditional gender roles. Angela Carter's "The Bloody Chamber" subverts fairy tale motifs, empowering female characters to navigate their destinies. Sarah Waters' "Tipping the Velvet" challenges Victorian gender norms, exploring intersections of gender, sexuality, and class. Akwaeke Emezi's "Freshwater" delves into Igbo spirituality, challenging binary understandings of gender with a character possessing fluid and multiplicitous identities.

#### **Agency and Empowerment**

Contemporary literature emphasizes characters' agency in shaping their identities. Colson Whitehead's "The Underground Railroad" follows Cora's escape from slavery, challenging racial and gendered expectations. Octavia Butler's "Parable of the Sower" features Lauren Olamina creating her own belief system in a dystopian future. Isabel Allende's "The House of the Spirits" explores empowerment across generations. Nnedi Okorafor's "Binti" showcases agency as the eponymous protagonist challenges tradition to attend Oomza University.

#### **Mental Health and Well-being**

Gender narratives explore the impact of societal expectations on mental health. Sylvia Plath's "The Bell Jar" and Jenny Han's "To All the Boys I've Loved Before" navigate the mental toll of conformity. Celeste Ng's "Little Fires Everywhere" discusses sexual orientation and mental well-being. Susanna Kaysen's "Girl, Interrupted" questions institutional responses to women's mental health. Alison Bechdel's "Fun Home" explores how societal expectations and familial dynamics impact mental health.

#### **Narrative Perspectives**

Diverse narrative perspectives enrich the exploration of gender experiences. Salman Rushdie's "Midnight's Children" delves into issues of identity in postcolonial India. Maxine Hong Kingston's "The Woman Warrior" blends autobiography with mythology. Madeline Miller's "The Song of Achilles" adds a queer lens to Greek mythology. James Baldwin's "Giovanni's Room" challenges conventional notions of masculinity and sexuality.

#### **Global Perspectives**

Contemporary literature transcends cultural boundaries to portray gender narratives globally. Haruki Murakami's "Norwegian Wood" explores relationships and gender roles in 1960s Japan. Arundhati Roy's "The Ministry of Utmost Happiness" spans India, navigating gender and identity in times of social and political upheaval. Nadine Gordimer's "Burger's Daughter" provides a global perspective on gender and political activism. Khaled Hosseini's "The Kite Runner" portrays masculinity in Afghanistan amid societal expectations.

#### **Evolution of Language**

Authors are conscious of language choices to reflect an expansive understanding of gender. Zadie Smith's "Swing Time" explores race, class, and gender with linguistic evolution. N.K. Jemisin's "The Fifth Season" introduces gender-neutral language in speculative fiction. Rupi Kaur's "Milk and Honey" offers modern language for discussing femininity, trauma, and resilience. Tayari Jones' "An American Marriage" explores love, fidelity, and gender expectations with language nuances.





## Zayana

### Critique of Stereotypes

Contemporary literature actively engages in the critique and subversion of gender stereotypes. Chimamanda Ngozi Adichie's "Half of a Yellow Sun" defies stereotypes associated with women in conflict zones. Naomi Alderman's "The Power" flips traditional power dynamics between genders. Alison Bechdel's "Fun Home" challenges stereotypes surrounding queer identities and family dynamics.

### Fluidity of Gender Identity

The fluidity of gender identity is a central theme in contemporary literature. Imogen Binnie's "Nevada" challenges binary understanding of gender. Leslie Feinberg's "Stone Butch Blues" delves into the experiences of a gender queer protagonist. Maia Kobabe's "Gender Queer: A Memoir" explores the diverse and fluid spectrum of gender expressions. Torrey Peters' "Detransition, Baby" navigates the complexities of transgender identity.

### Neuro diversity and Gender

Contemporary literature explores the intersection of neuro diversity and gender identity. Hanya Yanagihara's "A Little Life" delves into neuro divergent experiences. Helen Hoang's "The Kiss Quotient" intertwines autism spectrum disorder with romantic relationships. Jen Wilde's "Queens of Geek" showcases a character on the autism spectrum navigating love and friendships. Mark Haddon's "The Curious Incident of the Dog in the Night-Time" provides a unique perspective on autism.

### Exploration of Non-Binary and Agender Identities

Contemporary literature actively explores characters with non-binary and agender identities. Charlie Jane Anders' "All the Birds in the Sky" challenges traditional gender norms. Meg-John Barker and Alex Iantaffi's "Life Isn't Binary" explores non-binary identities. Malinda Lo's "Ash" features a non-binary character in a re imagined Cinderella story. Michelle Perez and Remy Boydell's "The Pervert" offers a portrayal of a trans woman navigating her identity.

### Gender queer Perspectives in Speculative Fiction

Speculative fiction explores gender cognitive variations through fantastical worlds. N.K. Jemisin's "The Broken Earth" trilogy challenges traditional gender norms. Ann Leckie's "Ancillary Justice" introduces an artificial intelligence protagonist navigating a society without fixed gender roles. Ursula K. Le Guin's "The Left Hand of Darkness" delves into a world where individuals are ambisexual. Brian K. Vaughan and Fiona Staples' "Saga" portrays a fantastical universe with characters embodying a wide spectrum of gender expressions.

### Historical Perspectives on Gender and Cognitive Diversity

Literature delves into historical settings to explore how cognitive variations in gender were perceived. Sarah Waters' "Affinity" explores spiritualism and mental health challenges in Victorian England. Emma Donoghue's "The Sealed Letter" delves into societal norms and perceptions of mental health intersecting with gender roles in the 19th century. Alice Walker's "The Color Purple" addresses the cognitive toll of societal expectations on African American women in the early 20th century. Jean Zimmerman's "Love, Fiercely" provides a historical perspective on gender dynamics and cognitive variations in 1920s New York.

## CONCLUSION

Contemporary literature emerges as a powerful tool unraveling the complexities of gender cognitive variations. From fluid gender identities to neuro diversity, non-binary perspectives, speculative explorations, and historical reflections, authors are weaving a rich tapestry that captures the diversity of human experiences. By embracing and exploring cognitive variations within gender narratives, literature becomes a potent medium for fostering understanding, empathy, and appreciation for the intricate nuances of identity. This study extends beyond literary analysis, prompting a reevaluation of societal norms and cultural expectations. It encourages a nuanced understanding of cognitive representations, paving the way for future research to delve deeper into specific cultural





### Zayana

contexts and genres, expanding our comprehension of how literature reflects and shapes cognitive experiences in the ever-evolving landscape of gender narratives.

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## Beyond Mourning: Empowerment of Widows in Cinema and Culture

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### ABSTRACT

The treatment of widows varies significantly across cultures, societies, and historical periods. In some cultures, widows face discriminatory practices, social stigma, or exclusion. In certain cultures, widows may face social ostracisation or discrimination due to traditional beliefs or superstitions surrounding widowhood. This can vary widely, from specific clothing to behavioural restrictions, and the duration of mourning can also differ significantly. Families, communities, or religious institutions might provide emotional support, assistance with household tasks, financial aid, or access to resources. Movies often portray the intense emotional journey of a widow dealing with grief, loss, and loneliness after the death of a spouse. Some movies highlight the social stigma and isolation that widows face, depicting their struggles to find their place in a society that might treat them differently after their spouse's death. These films might showcase how widows cope with changing relationships and social dynamics. Other movies focus on the empowerment and resilience of widows. This paper delves into how the widows are powerfully liberated from social constraints and pursue their own lives, by taking examples from the portrayal of widows in movies; Devaraagam [1996], Dor [2006] and Pagglait [2021]. The plight of widows is universal, the collective unconsciousness of human beings refers to a part of the unconscious mind shared by all humans, containing universal symbols, archetypes, and patterns inherited from ancestral experiences.

**Keywords:** Widow, Treatment of Widow, Movie, Collective unconsciousness.





**Najla and Aysha Muradh**

## INTRODUCTION

Widows in Indian society endure profound suffering, facing the harsh realities of patriarchal dominance. They endure physical and mental anguish without anyone to listen to or support them. In literature and film, these oppressed women are portrayed diversely. Widows are subject to the rigidity of both patriarchal and matriarchal systems, facing societal scrutiny regarding rituals, attire, diet, and a life of seclusion. Living with a husband places them within society, albeit in a subordinate role, often labelled as the "second sex." However, upon their husband's death, they plummet to society's lowest echelons, facing profound marginalisation and isolation. Indian literature poignantly reflects their plight, highlighting their marginalized existence and agonising solitude. Their appearance in white attire with shaven heads is startling, but the mental torment they endure is far more distressing. Society seems to revel in suppressing their desires, leaving widows stripped of individuality and deemed transgressors. Some, out of loneliness or necessity, might rely on a man who isn't their lover, unfairly labelled as a "vamp." Yet, a select few authors and filmmakers endeavour to depict widows as symbols of strength and self-assurance, challenging biased social norms. This paper titled "Beyond Mourning: Empowerment of Widows in Cinema and Culture" tries to bring to light some exceptional movies that dared to represent widows as an embodiment of self-confidence and self-esteem. By breaking the social constraints and stereotypes these specific widows try to bring a new face to widowhood.

### Collective Unconscious

The collective unconscious represents a part of the deepest unconscious mind believed to be inherited genetically rather than formed through personal experiences. This concept was initially formulated by the psychoanalyst Carl Jung. Jung theorised that the collective unconscious is an inherent layer of our unconscious mind present from birth, linking each individual to the historical thoughts and behaviours of all humanity and universal among all individuals. Additionally, he believed that this shared reservoir of the unconscious mind is responsible for housing fundamental beliefs and instincts. Jung proposed that the collective unconscious comprises a repository of inherent knowledge and imagery present in every individual from birth, shared among humanity through ancestral experiences. While people might not consciously recognize the content within their collective unconscious, Jung suggested that during moments of crisis, the psyche can access this reservoir. Think of the collective unconscious as an inherited 'database' or a vast computing 'Cloud.' It's an extensive reservoir of ancient knowledge accessible to everyone, enabling us to have shared human experiences when necessary. Jung posited that the collective unconscious finds expression through universal archetypes—symbols, patterns of thought, or behaviours inherited from our ancestors. Archetypes are universal concepts that we instinctively grasp, described by Jung as "identical psychic structures common to all." They enable us to share thoughts and ideas with individuals from diverse backgrounds and cultures, despite never having met them. These archetypes, in his view, aren't rigid; rather, multiple archetypes may intermingle or merge dynamically at any given moment. As Jung said, they can be seen as "the deposits of all our ancestral experiences, but they are not the experiences themselves". Similar to blueprints, archetypes transform into experiences when unconsciously enacted, often triggered by life events or challenges. Due to our unique encounters, we each utilize and express facets of the collective unconscious individually.

### Collective Unconscious And Widowhood

In societies where widows face discrimination or marginalisation, these attitudes can embed themselves within the collective unconscious. For instance, biases against widows—viewing them as symbols of bad luck, social outcasts, or imposing strict norms upon them—can seep into the collective unconscious, influencing perceptions and behaviours across generations. This collective imprint might contribute to stereotypes, stigmas, and prejudices that affect how widows are perceived and treated within a society. The mistreatment or neglect of widows throughout history could contribute to the formation of certain archetypes or symbols associated with their plight within the collective unconscious. These archetypes might manifest in cultural narratives, myths, or symbols, shaping societal attitudes toward widows. Here in this paper, the researchers take three archetypes put forward by Carl Jung to bring into light how the collective unconscious affects the life of widows and how it developed a stereotypical widowhood; The



**Najla and Aysha Muradh**

Persona, The Self and The Shadow. Persona represents the facade we present to the world, concealing our inner selves. The Self encompasses the entirety of one's personality, constituting the core of the complete psyche. Shadow signifies the unconscious, often darker or morally ambiguous aspects of the psyche. To showcase unconventional and empowered portrayals of widows, researchers have selected three films. "Devaraagam" [Bharathan,1996], "Dor" [Nagesh Kukunoor, 2006], and "Pagglait" [Umesh Bist, 2021] are three films that challenge and break stereotypical widow archetypes by portraying widows in unconventional and empowering roles.

**Portrayal Of Widowhood In Movies; "Devaragam", "Dor" And "Pagglait"**

In the intricate tapestry of widowhood, the collective unconscious exerts a multifaceted influence, encompassing both positive and negative dimensions. On the positive side, cultural support and rituals emanating from shared archetypes provide widows with a sense of community and shared experience. The Collective unconscious becomes a source of solace, fostering emotional resilience and a connection to broader narratives of strength in adversity. The archetypes of widowhood often vary across cultures and traditions. Commonly, they include symbols like wearing white or pale colours, removing jewellery, breaking bangles and adapting more subdued clothing. These practices often carry cultural and societal significance, reflecting mourning and the transition to a different marital status.

In all three movies set in three different states of India, the collective unconscious of the mob has a terrible impact on the further life of the widow. Even though there is cultural support from the people around the trauma they give through societal stigmas and judgemental attitudes towards them is killing them in one or the other way. In all three movies, they are asked to be confined to darkness or society tries to isolate the widows; Baagyalakshmi in Devaragam, Meera in Dor and Sandhya in Pagglait. Without considering them as human beings society compels them to follow oppressive cultural norms, society has already created a pattern on how the widow should behave, dress, or participate in social activities. The collective unconscious of the people around these widows is not allowed to break this pattern and instead forces them to accept it as it is.

In Devaragam, the women around her bring a dress that is symbolic of their widowhood, remove their vermilion, throw away the jasmine flowers from their hair and break the bangles. By this, they are enforcing rigid norms that constrain widows and hinder their ability to embrace personal freedom and individuality. "What should I do? Should I shave my head? Should I wear white? Should I confine my life in the dark without longing for anything?" (Baagyalakshmi, 2:21). The community's judgemental attitudes, influenced by shared cultural biases, exacerbate the widow. In Pagglait, Sandhya gets the title of madness when she laughs and is not provided with the food she likes to eat. Sometimes society just forgets the fact that these widows are also human beings and by taking the name of the collective unconscious they restrict the choices and autonomy of widows' lives. They are denied the opportunity to make decisions for themselves. In both the movies, Dor and Pagglait, Meera and Sandhya are not aware of the discussions going on in their house regarding their remarriage. Unfortunately, the negative impacts reach its peak when it deals with financial insecurity. All three widows are financially dependent and economic challenges are a huge threat in front of them. In Paggalit, Sandhya's mother is not willing to take her back as she has two more daughters to marry off. As an after-effect of the collective unconscious, society treats these financially dependent widows as a burden. As a result of this, the widow has to face emotional isolation where she finds no shoulder to lean. In Dor, Meera lives with her in-laws and her mother-in-law accuses her of being the reason behind her son's death and never tries to give Meera any kind of emotional support.

All the colourful dresses from her wardrobe have been substituted by a Blue saree which is symbolic of widowhood. Here the woman Meera loses all her identity and society gives her another identity as a widow. These negative aspects underscore the importance of challenging societal norms and promoting cultural shifts that empower widows to lead fulfilling lives beyond the confines of restrictive traditions and beliefs. The collective unconscious, when influenced by outdated norms, can perpetuate inequalities and hinder the well-being of widows, emphasising the need for broader social awareness and change. The process of breaking free from the collective unconscious in widowhood involves acknowledging and challenging societal norms, expectations, and beliefs surrounding widowhood. It entails recognising that individual experiences and responses to loss are unique, and not necessarily defined by societal constructs or expectations. Breaking collective unconsciousness in widowhood involves



**Najla and Aysha Muradh**

challenging and transforming societal norms and beliefs related to widows. Widows share stories and experiences to create awareness about the challenges faced by widows. Education can be a powerful tool for challenging misconceptions. Establishment of a support group for widows where they can share their experiences and receive emotional support. Building a sense of community helps combat isolation. The most important way to break the collective unconscious regarding widowhood is to Integrate education about widowhood and related issues into school curricula to foster understanding and empathy from a young age. Widows should be empowered by educating them about their legal rights. Support initiatives that aim to secure legal protection for widows against discrimination. Moreover, they should be given opportunities to gain skills and become financially independent. Economic empowerment can be a powerful means of breaking societal stereotypes. In addition to that offering psychological support and counselling services to widows, addressing the emotional impact of societal attitudes can help them to build resilience and empower them to challenge stereotypes. Intergenerational Communication is another facilitator of open communication between different generations within communities.

This can help challenge outdated beliefs and foster a more progressive understanding of widowhood. Breaking collective unconsciousness is a multifaceted process that involves addressing societal, cultural, and individual attitudes. Here the three widows are reflecting the Self (entirety of one's personality, constituting the core of the complete psyche) by breaking the collective unconscious. *Dor* and *Pagglait* are Bollywood films that have been praised for breaking traditional stereotypes and shedding light on the complexities of widowhood in Indian society. Both movies challenge societal norms related to widowhood in the context of Indian culture. The film follows the journey of two women from different backgrounds—one a widow seeking justice, the other the wife of a man on death row. The film portrays strong, resilient female characters who challenge the norms associated with widowhood. Their journeys emphasise individual agency and the pursuit of justice. "Sometimes listen to your mind and then you will live if you find a rhythm with it" (Zeenath; *Dor*). "I am leaving because the world is ready to decide what's best for women, but nobody stops for a second to ask women" (Sandhya; *Pagglait*) In "*Dor*", Meera's character gets liberation as a result of intergenerational communication. Even though it's her friend Zeenath who liberates her, it's the deed of the grandmother that paves the first step to that. Both movies explore the bond that develops between the two female protagonists, transcending societal expectations. This relationship challenges stereotypes and highlights the importance of empathy and understanding. "Don't get angry friend, I can fight, I can refuse too" (Zeenath; *Dor*), here she helps her friend to come out of the frustration and isolation. In "*Pagglait*", Sandhya does all her likes and fulfils her wishes with the help of her female friend. Sandhya goes to a cafe to have spicy food which is restricted for her.

Here her female companion helps her to break the isolation. The narrative challenges the prevalent mindset by focusing on justice and empathy rather than conforming to societal norms. "I have snatched away my rights from time immemorial" (Zeenath ;*Dor*), "No one gives power to the mind other than self" (Meera; *Dor*). In "*Devaragam*", instead of confirming the societal norms and leading a dark life Baagyalakshmi chooses her life which is full of colours. It encourages viewers to question and reflect on the treatment of widows in certain cultural contexts. These three characters help to break the stereotypes and the collective unconscious which was then prevalent in their society. The films explore family dynamics and societal pressures surrounding the widow, highlighting the conflicts and contradictions that arise. This contributes to a nuanced portrayal that challenges collective unconsciousness. "*Devaragam*", "*Dor*" and "*Pagglait*" contribute to breaking collective unconsciousness by presenting nuanced and empathetic portrayals of widowhood. They encourage audiences to question societal norms and reflect on the individual experiences and agency of widows, fostering a more inclusive and progressive perspective.

**CONCLUSION**

The portrayal of widows in Indian society is deeply entrenched in societal norms and collective unconscious biases that impose profound suffering and isolation. Throughout history, widows have faced harsh realities dictated by



**Najla and Aysha Muradh**

patriarchal dominance and societal scrutiny, often losing their individuality and agency. The collective unconscious, shaped by cultural beliefs and ancestral experiences, perpetuates stereotypes, stigmas, and prejudices that marginalize and oppress widows. However, certain literature and films, like "Devaragam," "Dor," and "Pagglait," stand as beacons challenging these ingrained perceptions. These works depict widows as symbols of strength and self-assurance, breaking away from the shackles of societal norms. They shed light on the individual agency and resilience of widows, showcasing their struggles, aspirations, and the complexities of their lives beyond societal constraints. These narratives not only challenge societal norms but also encourage audiences to question and reflect on the treatment of widows. They emphasize the importance of empathy, understanding, and intergenerational communication in empowering widows to reclaim their individuality, rights, and place in society. By portraying nuanced and empathetic depictions of widowhood, these works contribute to breaking the collective unconsciousness, fostering a more inclusive and progressive perspective toward widows in Indian culture.

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## Gendered Cultural Norms: The Maternal Authority Paradox In Kerala's Muslim Marriages

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### ABSTRACT

The shifting dynamics within Muslim households in Kerala have drawn attention to the rising divorce rates, primarily attributed to the intricate interplay between gender-specific conduct and familial authority. The pivotal roles of the mother-in-law and the societal expectations placed on wives have created a distinctive cultural norm, often overshadowing the principles outlined in religious teachings. In this cultural milieu, upon marriage, the mother of the husband assumes an authoritative role that surpasses the agency of the wife's mother. This power dynamic often leads to a situation where the wife's family is expected to be subservient and acquiescent to the demands of the husband's mother. Failure to meet these expectations can lead to the wife being deemed insufficient and her family, vulnerable to censure. Additionally, traditions that require the wife to seek permission before visiting her own parents reflect the deeply entrenched control wielded by the husband and in-laws over her autonomy. Surprisingly, these expectations, though culturally ingrained, find no basis in religious scriptures, creating a paradox between cultural tradition and religious doctrine.

**Keywords:** maternal authority, culturally ingrained, religious doctrine.





**Jouhara****INTRODUCTION**

In the intricate web of sociology and cultural norms, a silent narrative unfolds—the struggles faced by women in Muslim marriages in Kerala. Rooted in time-honoured traditions, these dynamics paint a nuanced picture laden with expectations, especially for daughters-in-law. This exploration delves into the choreography of gendered behaviors, societal expectations, and the influence held by female members within familial constructs. It uncovers a rich tapestry woven with cultural norms, where women's roles, prospects, and limitations in marital homes are entangled with society's perceptions and gender-based behaviors. In the realm of Muslim households in Kerala, wives' experiences reveal a poignant reality, often marked by impactful hardships, particularly from mothers-in-law. These adversities encompass emotional distress, relentless scrutiny, and constraints on personal liberties. The enduring pressure to conform to predefined roles and the underappreciated influence of mothers-in-law create an environment that can suffocate, induce emotional strain, and erode agency for daughters-in-law. It's indeed a paradoxical backdrop against the principles of Islam, a religion that inherently champions freedom and empowers women across various spheres. Nevertheless, within the microcosm of familial structures, these hidden adversities intricately interwoven into the fabric of daily life significantly shape the emotional landscape for women in Muslim marriages within Kerala. Examining women's rights in Islam, two papers, "The Historical Evolution of International Humanitarian Law (IHL) from Earliest Societies to Modern Age" and "An Eastern Perspective: The Relationship Between Mother-In-Law And Daughter-In-Law," highlight distinct aspects. The former explores international humanitarian law, while the latter delves into Eastern dynamics between mothers-in-law and daughters-in-law.

My research aims to disentangle Islam from blame for human rights violations in Kerala Muslim marriages. Scrutinizing these papers unveils nuanced perspectives, contributing to a comprehensive understanding of the interplay between culture, gender, and religious practices in this context. In Kerala Muslim weddings, providing abundant 'salkaram' food indirectly scrutinizes the bride's family's financial status. There's an ongoing expectation for the bride's family to consistently honour and respect the husband's family, assessing financial capacity. Cultural practices create expectations and perpetuate societal norms. Post-wedding, rituals impose financial strain on the bride's family, requiring gifts, annual kitchen essentials, and providing food during visits. Pregnancy escalates financial responsibilities on her parents, burdening the bride's family and reinforcing societal perceptions of daughters as 'burdens' entrenched in cultural expectations. In some Muslim households, a traditional custom involves the mother-in-law taking all gold jewelry from the daughter-in-law after marriage, storing it and retaining the key. The gold is only returned temporarily for specific events and then promptly taken back. In-laws often set strict expectations, including dowry demands, traditionally in gold and money. Despite discouragement of dowry, the insistence on gold persists due to concerns about unequal inheritance. Unfortunately, post-marriage, husbands may exhibit greed demanding more wealth perpetuating the idea of women as burdens, causing suffering and societal pressures. Disparities between the treatment of the bride's mother and the husband's mother arise from cultural norms, elevating the status of the husband's mother as the 'mother-in-law.'

This power dynamic, favouring the husband's side, grants them unique authority in the family structure, particularly after their sons are married. Interestingly, this authority doesn't emerge when their daughters marry, creating an unequal relationship. Some mothers-in-law continue to refer to sons-in-law as 'puthiyappla' or 'newcomer,' even when they with have grandchildren. Unfortunately, these imbalances often persist unquestioned, challenging women to change or challenge these dynamics due to long-standing cultural obligations and acceptance. In 2021, India recorded around 6.8 thousand dowry deaths, marking a decline from approximately 8.5 thousand in 2014. Kerala, known for its progressive stance, faced a tragic suicide case involving a PG doctor pressured for a hefty dowry. The state reported 25, 12, and 17 dowry fatalities in 2016, 2017, and 2018, with minor declines in subsequent years. In 2021 and 2022, Kerala documented 4,997 and 4,998 cases of abuse by spouses or family members. Over five years, 66 dowry deaths and 15,143 harassment cases were reported. Despite high literacy rates, the societal issue persists, as highlighted by the Kerala High Court acknowledging subsequent dowry demands triggering legal definitions. Unfortunately, societal values still prioritize men, perpetuating the prevalence of dowry practices. In





**Jouhara**

Kerala, financial gains from a son's marriage often overshadow the essence of marital unions, revealing a paradox in the state's social indicators and literacy rates not directly correlating with solving deep-rooted social problems. Arranged marriages are influenced by power dynamics and societal judgments from the beginning, such as during 'pennukanal' rituals. Elderly women often wield significant influence, vetoing matches based on trivial criteria like appearance or even eyeglasses. These stringent standards impact a girl's marriage prospects, perpetuating shallow judgments. In love marriages, the husband's family may express contempt, often starting with criticism of the girl's appearance. There's a pervasive societal notion that allows a man to be less attractive while expecting the woman to be conventionally beautiful, overlooking her other qualities. Comments blaming the girl and disregarding mutual decision-making are common, perpetuating a double standard where the girl's family faces scrutiny while the boy chooses freely. This sustains the power and privilege men have in choosing partners, while women are expected to conform and maintain a culturally appropriate image. Unfair expectations and judgmental behavior toward women in relationships result from these societal attitudes. Dynamics within the husband's family, especially involving the mother-in-law and sisters-in-law contribute to issues. There's a belief that the girl 'stole' their son or brother away, impacting discussions about the couple's independence and decision-making within the family.

India values close-knit family structures, emphasizing living together after marriage for familial bonds and support. However, this tradition can pose challenges, particularly for wives, as the expectation to please the entire family becomes burdensome. This disproportionate burden often leads to stress, emotional strain, and potential domestic conflicts or abuse. The pressure to maintain familial harmony may overlook the wife's needs, contributing to strained relationships. In Kerala weddings, a post-wedding tradition involves relatives evaluating the bride's appearance and skills, emphasizing culinary abilities as crucial for marital success. This mindset, linking a woman's worth to domestic skills, diminishes the importance of her education and moral integrity. Establishing healthy boundaries, even with in-laws, becomes crucial to navigate these challenges. This practice assigns significant importance to a woman's adherence to traditional gender roles, particularly in cooking and cleaning for her husband's family. Unfortunately, academic achievements and personal character often take a backseat in evaluating her individual worth. It reflects a societal belief that a woman's primary role centers around domestic responsibilities, overlooking her multifaceted capabilities and qualities. In Muslim marriages, there's emphasis on the bride's proficiency in preparing non-vegetarian dishes. A light-hearted saying highlights the cultural importance of meat consumption, suggesting those who don't procure meat on Fridays may be considered outside Islamic norms. While colloquial, it underscores the significance of non-vegetarian foods in Muslim communities.

Brides are expected to excel in cooking, especially non-vegetarian dishes, receiving additional acknowledgment for catering to larger gatherings. This expectation aligns with the cultural significance of food in uniting families and communities, valuing the ability to cook meat-based meals for larger groups. Politics surrounding food and finances in Muslim households can be intricate. Serving beaten rice or suggesting simple meals may invite criticism, associating them with beggars or financial instability. Wives navigate a delicate balance, avoiding being labeled spendthrift or excessively accommodating. Financial challenges often result in blaming the wife, with the mother-in-law sometimes suggesting she's a 'bad luck' omen. These dynamics create a challenging environment where the wife's actions are scrutinized and criticized, impacting her role within the family. In some households, wives facing health issues are criticized for the financial burden, while husbands receive care and sympathy when unwell. In rural and middle-class marriages, wives are pressured to seek pregnancy-related care at government hospitals, emphasizing frugality over potential healthcare benefits. This discrepancy in expectations and treatment highlights deeply ingrained gender biases, where wives face scrutiny for health expenses while husbands receive understanding. These societal pressures place undue burdens on wives, impacting their access to healthcare and support during times of need. A power dynamic exists where husbands and mothers-in-law assert authority over children, limiting the mother's say in their upbringing. Mothers-in-law often prioritize their sons' children, considering them primarily part of their households, while daughters' children are seen as guests. This unequal treatment stems from societal norms where daughters are groomed for marriage, and sons are expected to stay with their parents. This focus on sons can create challenges for wives, pressuring them to prioritize husbands over in-laws to avoid being labelled as uncaring. Blame may be placed on daughters-in-law for sons' increased involvement in



**Jouhara**

household chores, perpetuating gender roles and influencing perceptions of responsibilities. The dynamic between mothers-in-law and daughters-in-law can lead to tensions, reflecting broader societal norms and expectations.

In certain households, wives face significant restrictions and lack autonomy, akin to living as servants in their husband's family. Movement is curtailed, requiring permission not only from the husband but also from in-laws for simple outings or staying at their own house. Obtaining permission resembles a bureaucratic procedure, making spontaneity difficult, often resulting in cancelled plans. Seeking approval to reconnect with her own family, even her parents, takes an emotional toll on the wife. Throughout her life, a woman prioritizes her husband's family, enduring emotional distress. Even if her husband permits meeting friends, the mother-in-law opposes it, expecting the daughter-in-law to let go of her previous life. This contradiction highlights women being their harshest critics, limiting the daughter-in-law's autonomy in various aspects, enforced by women in rural households rather than men. This contradicts the notion that men are solely responsible for such limitations. Societal pressure on women to quickly conceive defines their worth, overshadowing dreams and aspirations. Challenges in conceiving lead to relentless torment, even if the issue lies with the husband. If she has children, she faces scrutiny for not being a 'good enough' mother, perpetuating the notion that the wife is always at fault. In traditional settings, a woman's post-marriage journey involves a significant shift, prioritizing her husband's family above her own needs and desires.

This expectation, reinforced by both the husband and the mother-in-law, adds complexity with the contradictory nature of these expectations. Mothers-in-law reminisce about their sacrifices but endorse similar expectations for the daughter-in-law, creating a perplexing cycle of recounting past sacrifices while perpetuating these norms onto the younger generation. As a result, it is clear that the control and limitations imposed on the daughter-in-law aren't solely orchestrated by men; instead, it's often the women in the household who enforce and regulate these restrictions. This contradicts the common assumption that men are solely responsible for restricting a woman's freedom or autonomy. The control over her choices—be it in her appearance, expression, or personal time—is often wielded by the older women in the family, leading to a complex dynamic where female relatives become the gatekeepers of societal norms and limitations imposed on the daughter-in-law. These expectations and restrictions perpetuate a cycle where women, consciously or unconsciously, become complicit in enforcing societal norms and limitations on other women, thus perpetuating a cycle of control and restriction within the household. This complex interplay of expectations, regrets, and enforcement of norms highlights the nuanced dynamics within traditional family structures, where control isn't solely wielded by men but is also deeply ingrained within the female members of the household. It's disheartening to witness how these practices, often practised in the name of culture or religion, create an environment where women are subjected to emotional distress, limitations on autonomy, and unjust blame for societal norms they didn't create. This is especially prevalent in instances where these practices are erroneously attributed to Islam. In many Muslim families, there's a strong cultural expectation to fulfil rituals and please in-laws, almost as if one's spiritual destiny hinges on it.

However, while Islamic teachings emphasize kindness towards family members, including in-laws, there's no explicit mention in the Quran or Hadith about specific duties towards in-laws. The focus primarily rests on fulfilling the responsibilities towards one's spouse and treating everyone with kindness and respect. According to Islamic teachings, a wife's duty to care for her husband is contingent upon him being a righteous and honourable individual. These interpretations can vary among families based on their cultural backgrounds and personal beliefs but nowhere it should be an obligation in the name of religion. Under Islamic feminist principles, stressing the significance of a wife's consent extends beyond marriage to encompass decision-making and matters impacting her life, prioritizing her agency and independence. This includes acknowledging her right to decline responsibilities like feeding her child or managing household duties if she chooses. Additionally, she isn't obligated to cater to her husband's entire family. It's regrettable that numerous practices, often misrepresented as religious obligations, disregard these fundamental rights of women. These interpretations and actions contradict the essence of gender equality advocated by Islamic feminism, fostering a need for more accurate and fair portrayals of women's rights within the Islamic context. The religion itself promotes harmony and mutual respect within marriages, emphasizing kindness and understanding between spouses. Islam advocates for the rights and dignity of women, highlighting their role as equal partners in a marriage based on mutual consent and respect. The teachings stress the importance of a husband



**Jouhara**

being righteous and just, deserving of the kindness and support of his wife. However, these cultural practices, far removed from the essence of the religion, impose burdensome expectations on women, often fueled by societal judgments and entrenched gender biases. These practices lead to undue pressure, emotional distress, and limitations on a woman's individuality, contrary to the principles of Islam. It's essential to recognize that the oppressive dynamics within certain households, enforced by cultural norms rather than religious teachings, undermine the true essence of Islam. The religion never intended for a wife to suffer or endure emotional distress within a marriage. Instead, it aims to foster peace, understanding, and respect between spouses, rooted in mutual care and compassion. Ending these atrocities against women, perpetuated under the guise of culture or religion, requires a collective effort aligned with Sustainable Development Goals (SDGs) set by the United Nations. Initiatives aimed at fostering awareness, initiating conversations, and educating communities align with SDG 5, which seeks to achieve gender equality. By challenging and dismantling harmful practices, particularly within the framework of true Islamic teachings that emphasize equality, respect, and mutual understanding between spouses, we contribute to SDG 5's mission of empowering women and promoting their rights and well-being. Creating a clear distinction between cultural practices and religious teachings aligns with the broader SDG agenda, promoting inclusivity, justice, and ensuring that no one is left behind.

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## Collective Experience and Socio-Cultural Trauma: An Analysis of Gloria Naylor's *The Women of Brewster Place* and *Linden Hills*

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### ABSTRACT

Numerous problems and tribulations people face around the world, might lead to stress or despair in their lives. Trauma is the outcome of an event, sequence of events, or collection of circumstances that an individual perceives as harmful to their physical or emotional well-being or as potentially fatal. It negatively impacts the individual's as well as the community's functioning and well-being persistently. Jeffrey C Alexander, an American Sociologist says when people collectively believe that they have experienced a horrific incident that permanently alters their memories and fundamentally alters their identity going forward, they are said to have experienced cultural trauma. Gloria Naylor's novels, *The Women of Brewster Place* and *Linden Hills* deal with the issues of the African-American community that experiences sociological harm, racial and gender discrimination, poverty and urban struggles, intersectionality, community and isolation, social hierarchies and class division, community expectations, and many other societal issues. In both novels, the community collectively collapsed, abandoned, and misbegotten. The characters in the novels come to terms with socio-cultural traumatizing experiences in their social situations. This article critically analyses the dynamics of socio-cultural trauma in these novels.

**Keywords:** Social issues, Cultural trauma, Discrimination, Violence, Collective memory and identity, Intersectionality.



**Sindhiya and Cinthia Jemima****INTRODUCTION**

Gloria Naylor (1950–2016) was an acclaimed African American novelist known for her powerful storytelling and exploration of the complexities of African American life, particularly the experiences of African American women. Born on January 25, 1950, in New York City, grew up in a religious and socially conscious family. Her works often delved into issues of race, gender, and socio-economic challenges faced by individuals within their communities. Naylor's writing is characterized by its exploration of the African American experience, with a particular focus on the lives of African American women. Her works often touch on themes such as identity, community, family dynamics, and the impact of societal structures on individuals. Naylor gained widespread recognition with her debut novel, *The Women of Brewster Place*, published in 1982. The novel won the National Book Award for First Fiction. The novel is a poignant exploration of the lives of seven African American women living in a housing project in an urban setting. Through interconnected stories, Naylor addresses issues of poverty, discrimination, and the strength of female bonds, capturing the resilience and struggles of the characters. The major themes of *The Women of Brewster Place* are female solidarity and friendship, poverty and discrimination, identity and empowerment, resilience and survival. *Linden Hills* is another significant work by Gloria Naylor, exploring the consequences of social ambition and the pursuit of success in an affluent African American community. The novel, named after the fictional affluent neighborhood it portrays, delves into the impact of socio-economic status on personal relationships and the cost of achieving the American Dream. *Linden Hills* delves into themes of socio-economic ambitions, critiques of materialism, identity, and the sacrifices demanded by societal norms, with the characters serving as conduits for these explorations. Naylor skillfully weaves a narrative that examines the sacrifices individuals make in the pursuit of material success and societal acceptance. She continued to produce significant works, including *Mama Day* (1988), *Bailey's Cafe* (1992), and *The Men of Brewster Place* (1998), a follow-up to her first novel.

The purpose of the article is to conduct a comprehensive literary analysis of Gloria Naylor's novels, *The Women of Brewster Place* and *Linden Hills*, utilizing Jeffrey C. Alexander's socio-cultural trauma theory as a conceptual framework. The aim is to explore and dissect the representation of collective experience and socio-cultural trauma within the narratives of these works. By applying Alexander's theoretical framework, the article seeks to examine traumatic events, understand collective experience, apply socio-cultural trauma theory, explore symbolism and cultural significance, conduct a comparative analysis, evaluate strengths and limitations, contribute to literary discourse, and offer implications for further research. The main arguments of the article revolve around the application of Jeffrey C. Alexander's socio-cultural trauma theory to analyze the novels *The Women of Brewster Place* and *Linden Hills* by Gloria Naylor. Both novels depict significant traumatic events that profoundly affect the characters and communities. The analysis aims to identify and understand the nature of these events, exploring their emotional and psychological impact. Jeffrey C. Alexander's theory is employed to frame traumatic events within a social context. The theory helps interpret how these events are constructed and experienced collectively, considering the societal structures that contribute to the trauma. Characters in Naylor's novels share a collective experience of trauma, forming interconnected narratives that contribute to a communal understanding of suffering. The analysis delves into the ways in which trauma shapes the character's identities and relationships within the community. Impact of immigration on identity, discussing the challenges, treatment, and transformative potential of the experience. It also provides insights into psychological and socio cultural aspects of immigration and identity [4]. Gloria Naylor's novels, *The Women of Brewster Place* and *Linden Hills*, explore the themes of collective experience and socio-cultural trauma. In *The Women of Brewster Place*, the concept of Black Sisterhood is examined, highlighting the mystical relationship between women supporting each other despite their burdens. The novel portrays the ways in which black women overcome oppression and marginalization, influenced by the Black Feministic Movement and other Black Liberation Movements. Additionally, the novel emphasizes the importance of shared memories and dreams as a healing device and a mechanism for collective consciousness, enabling the women to challenge pain and fulfill their quest for selfhood and emancipation. These themes of collective experience and trauma are also relevant in *Linden Hills*, as it follows the emotional responses of a bicultural woman who experiences adversity and witnesses collective upheavals. The challenges faced by African American women during the Great Migration and the





**Sindhiya and Cinthia Jemima**

importance of community and safe spaces for their survival. It specifically analyzes the migrant stories of African American women [2]. Moral corruption and spiritual emptiness in an American black bourgeois neighborhood are depicted in Gloria Naylor's novel *Linden Hills*, which focuses on the disintegration of community values and the experiences of black female characters [3].

**Socio-Cultural Trauma**

Gloria Naylor's contributions to American literature extend beyond her works. Through her novels, she provided a unique and insightful perspective on the experiences of African American women and the broader challenges faced by African American communities. *The Women of Brewster Place* and *Linden Hills* stand as literary landmarks, showcasing Naylor's ability to explore complex social issues with compassion and nuance, making her a pivotal figure in contemporary African American literature. The relevance of socio-cultural trauma in literary analysis lies in its ability to provide a framework for understanding and interpreting the impact of collective experiences on individuals and communities within the context of a particular society. Socio cultural trauma theory examines the impact of traumatic events on societies and communities, emphasizing the broader social, cultural, and historical contexts that shape individual and collective responses to trauma. It's a form of trauma about the experience of marginalized and oppressed people. The impact of the toxic stress on people remains unresolved trauma triggers a response of either fight, flight, or freeze. In people of color (BIPOC i.e. Black, Indigenous, and People of Color), these responses have often been mislabelled as defiant rather than protective, oppositional rather than guarded, disinterested but more accurately assessed as emotionally numb.

Socio cultural trauma is caused by physical, social, or psychological assaults on an individual or group based on their racial or ethnic identity, socioeconomic status, gender identity, abilities, religious belief or lifestyle. Socio-cultural assaults can be implicit, making them unpredictable and unavoidable. This can have cumulative effects on physical, health, mental health, and health behaviors. A trauma response can be inherited from one's parents or from everyday societal factors and events. Individual's responses to trauma can be further precipitated by a biased treatment that one's parents, community, or ethnic group have experienced throughout history. The understanding of traumatic experiences, attitudes toward individual accountability, and acceptance of symptoms and seeking assistance are all influenced by culture. It is essential for mental health professionals to be aware of socio-cultural trauma, and treatments for individuals, families, and children should be based on an all-encompassing, culturally sensitive, trauma-informed approach.

Literary works often serve as mirrors reflecting the complexities of human existence, and socio-cultural trauma theory offers a lens through which we can analyze the profound effects of shared traumatic events. Socio-cultural trauma theory enhances literary analysis by providing a conceptual framework to delve into the intricate relationships between individual experiences, societal structures, and collective trauma. It offers a way to interpret the symbolic and cultural dimensions of literature, enriching our understanding of the profound impact of shared traumatic events on both fictional characters and real-world communities. Socio-cultural trauma theory enables readers and analysts to identify and dissect the shared experiences that characters undergo, reflecting broader societal realities. It allows the examination of how traumatic events become embedded in the cultural consciousness, influencing the narratives and stories that communities tell about themselves. The theory is applied to explore the social bonds formed in response to trauma. It helps illuminate how collective experiences contribute to the formation of communal identity and resilience.

Literary devices and symbols are used in the novels to represent trauma, and these carry cultural significance. The analysis aims to decode the symbolism and explore the cultural dimensions embedded in these representations. Alexander's framework is utilized to interpret the symbolic elements in the context of collective memory. The theory aids in understanding how cultural narratives contribute to the broader societal understanding of trauma. A comparative analysis is conducted to identify similarities and differences in the portrayal of trauma in *The Women of Brewster Place* and *Linden Hills*. The focus is on exploring thematic variations and any evolution in the representation of socio-cultural trauma across the two works. The theory provides a framework for comparing the socio-cultural dynamics of trauma in different contexts. It helps identify overarching patterns and themes that contribute to the





**Sindhiya and Cinthia Jemima**

overall narrative. The article critically assesses how well Jeffrey C. Alexander's socio-cultural trauma theory captures the nuances of trauma in Naylor's novels. The evaluation includes a discussion of the strengths of the theory in enhancing literary analysis and an acknowledgment of any limitations. The theory's role in shaping the overall analysis is reiterated, emphasizing its contributions to a deeper understanding of collective experiences in literature. Potential avenues for future research are suggested, building on the insights gained from applying the theory. In essence, the main arguments of the article focus on leveraging Jeffrey C. Alexander's socio-cultural trauma theory to dissect and interpret the representation of trauma in Gloria Naylor's novels, providing a nuanced understanding of how collective experiences shape the narrative and contribute to cultural memory. Jeffrey C Alexander is a prominent American Sociologist known for his work on cultural sociology, social theory, and the study of collective memory and trauma. In his collaborative work, the book *Cultural Trauma and Collective Identity* (2004) states that "Cultural trauma occurs when members of a collectivity feel they have been subjected to a horrendous event that leaves indelible marks upon their group consciousness, marking their memories forever and changing their future identity in fundamental and irrevocable ways" [1] (Alexander JC 2004). It discusses how societies collectively respond to traumatic events and how cultural meanings are disrupted and reconstructed. Cultural trauma is first of all an empirical, scientific concept, that suggests new meaningful and causal relationships between previously unrelated events, structures, perceptions, and actions. The key concepts presented encompass various aspects of trauma theory, cultural studies, and social psychology. They are as follows

1. Identification of Traumatic Events
2. Symbolic Dimensions of Trauma
3. Collective Memory and Identity
4. Narrative Construction
5. Public Sphere and Cultural Discourse
6. Symbolic Resources for Coping
7. Impact on Social Structures

Understanding these key concepts is essential for exploring the complex interplay between trauma and cultural, social, and individual experiences. Each concept contributes to a comprehensive understanding of how trauma is identified, expressed, and integrated into the broader fabric of collective and individual identities. Analyzing collective experiences and socio-cultural trauma in literature holds significant importance as it provides a nuanced understanding of the broader societal impact of traumatic events. Through literature, the cultural nuances, shared memories, and coping mechanisms of communities facing trauma are explored, contributing to a comprehensive exploration of the human condition. It allows for a deeper examination of how collective identities are formed, cultural narratives are constructed, and communities navigate and respond to shared traumas, fostering empathy, awareness, and critical insights into the complex interplay between individuals and their sociocultural contexts.

**Collective Traumatic Experiences****Identification of Traumatic Events**

In *The Women of Brewster Place*, the demolition of the wall represents a traumatic event, symbolizing the destruction of communal bonds. In *Linden Hills*, the revelation of hidden injustices serves as an identified traumatic event, challenging the facade of affluence.

**Symbolic Dimensions of Trauma**

The wall in *The Women of Brewster Place* symbolizes the barriers and struggles faced by the women, while the tree becomes a symbol of resilience. In *Linden Hills*, the willow tree carries symbolic significance, representing both beauty and the dark secrets of the community.

**Collective Memory and Identity**

*The Women in Brewster Place* share a collective memory of hardships, contributing to the formation of a resilient communal identity. In *Linden Hills*, the revelation of hidden injustices challenges the community's collective memory and prompts a re-evaluation of their identity.





### Sindhiya and Cinthia Jemima

#### **Narrative Construction**

The narratives in both novels construct that give meaning to the character's experiences. In *The Women of Brewster Place*, the interconnected vignettes form a collective narrative of survival, while in *Linden Hills*, the linear narrative constructs a tale of societal expectations and hidden trauma.

#### **Public Sphere and Cultural Discourse**

The novels depict the public sphere through the character's interactions, conversations, and communal responses. In *The Women of Brewster Place*, the women's stories become part of the public discourse within their community. In *Linden Hills*, societal expectations and secrets contribute to the cultural discourse within the affluent neighborhood.

#### **Symbolic Resources for Coping**

Cultural elements such as blues music in *The Women of Brewster Place* serve as symbolic resources for coping, providing characters with a means of expressing and dealing with their emotions. In *Linden Hills*, naming traditions and the willow tree become symbolic resources that characters draw upon to navigate the challenges of societal expectations.

#### **Impact on Social Structures**

Traumatic events impact social structures in both novels. In *The Women of Brewster Place*, the demolition of the wall affects the community's social dynamics. In *Linden Hills* the revelation of injustices challenges the social structures built on success and conformity, prompting a re-examination of the community's values. Applying these key concepts to the novels allows for a comprehensive analysis of how trauma is identified, symbolically represented, integrated into collective memory, and navigated within the broader cultural and social context of each narrative.

#### **Surmounts of the Victims**

In Gloria Naylor's works *The Women of Brewster Place* and *Linden Hills*, characters collectively experience trauma in the context of their respective communities. The collective experience of trauma is a central theme in both novels, shaping the identities and relationships of the characters. Mattie and Eva collectively experience the trauma of loss, displacement, and the disruption of their homes. The women of Brewster Place collectively face discrimination and economic struggles. The experiences of Cora Lee, who undergoes a traumatic abortion due to societal judgment, and Ciel, who faces rejection based on her sexual orientation, highlight the broader societal issues affecting the community. The women form a collective identity through their shared adversities. Their stories of resilience, friendship, and communal support demonstrate how trauma can strengthen social bonds. Trauma is transmitted across generations, as seen in the struggles of characters like Ben, whose impoverished upbringing reflects the systemic issues affecting the community. The impact of trauma is interwoven with the character's familial and communal relationships. Characters in *Linden Hills* collectively experience trauma related to socioeconomic pressures and societal expectations. The pressure to conform to a certain standard of success creates a pervasive sense of anxiety and dissatisfaction. Characters like Willie and Lester collectively grapple with issues of identity within the affluent community. The trauma arises from the tension between personal desires and the expectations imposed by *Linden Hills*, leading to internal conflicts. The climax of the novel reveals hidden injustices and traumatic events within *Linden Hills*. The community's pristine facade is shattered, exposing the dark undercurrents that challenge the collective narrative of success. Characters like Teresa and Valerie collectively experience trauma related to isolation and alienation. The pressure to conform isolates individuals who do not fit the mold, leading to a shared sense of loneliness. The characters face collective struggles and they find strength through the formation of collective identity, strength in female bonds, resilience and survival, impact on future generations, public discourse and cultural memory.



**Sindhiya and Cinthia Jemima****CONCLUSION**

One important finding in the study of collective trauma is the profound impact it can have on collective memory and identity. Collective trauma, such as significant historical events or experiences shared by a community, can shape the way a group remembers its past and forms a collective identity. The shared experience of trauma often becomes a central narrative in the community's history, influencing its values, cultural expressions, and sense of solidarity. This finding underscores the intricate relationship between historical events, shared memory, and the formation of a collective identity within a community or society. The sub-theme inter sectionality of trauma in the context of this article would involve exploring how different intersecting factors, such as race, gender, class, and other social categories, contribute to a nuanced understanding of collective trauma experiences within the communities depicted in Gloria Naylor's *The Women of Brewster Place* and *Linden Hills*, using Jeffrey C. Alexander's socio-cultural trauma theory. The strengths of the theory are highlighted in its effectiveness in analyzing literature. Limitations are discussed with a nuanced perspective, considering alternative frameworks where applicable. The article concludes by summarizing key findings and reinforcing the significance of socio-cultural trauma theory in literary analysis. Broader implications for understanding the intersection of literature, trauma, and societal dynamics are discussed. Holistic understanding, cultural sensitivity, collective memory emphasis, inter sectionality consideration, and public discourse focus are the strengths of applying Socio-Cultural Trauma Theory. Potential oversimplification, cultural relativism challenges, and under emphasis on individuality are the limitations of this article. While socio-cultural trauma theory provides valuable insights, its application should be complemented by other perspectives to capture the full spectrum of individual and collective experiences in the context of trauma. Several areas that offer opportunities for further research and exploration are Comparative Analysis of Cultural Expressions, Transnational Perspectives on Trauma Narratives, Digital Narratives and Collective Memory, and Digital Humanities and Literary Analysis.

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## Indianness Within Superhero/heroine Protagonists in COVID-19 Health Literacy Comics: A Graphical Exploration from a Gendered Lens

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### ABSTRACT

The COVID-19 phase before pharmaceutical and scientific interventions relied heavily on non-pharmaceutical preventive methods by creatively manipulating social media strategies. Indian COVID-19 comics released are mainly focused on child audiences and are from a health literacy perspective. An exploration of these comics indicates that an element of Indianness is explicitly visible, especially within the superhero and super heroine protagonists, as an attempt to create a certain degree of relatability and inculcate an idea of reclaiming the roots. This paper analyses two select Indian COVID-19 comics: *Priya's Mask* (2020) and *Nagaraj Strikes: The Attack of Coronaman* (2020), where a super heroine and a superhero are the protagonists, respectively. The agenda is to decipher the element of Indian ness expressed and how the portrayal varies along the gender of the superhero/heroine protagonists using the method of discourse analysis aided by the graphic theories of Scott McCloud. The focus occurs explicitly on the choice of the two protagonists, Nagaraj and Priya, and their mythological significance. This would be explored via a gendered lens, focusing on the comic characters' sartorial, physical, and physiognomic aspects. Using Judith Butler's concepts, the comics would be examined to understand how the social constructs on gender are further affirmed through the performative act of creating superhero/heroine comics. Post the dawn of COVID-19, the health authorities have significantly shifted to digitized multimodal Information and Communication methods to promote health literacy, thus revamping these pedagogical tools in a way that suits the Indian audience helps the knowledge and information disseminated to reach a larger audience in a country like India. Studying the same from a gendered lens reveals the twin sides of the psyche of the makers and the influence of the same on the consuming target audience.

**Keywords:** COVID-19, Health literacy, Indian Comics, Physiognomic, Super hero/super heroine





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## INTRODUCTION

### COVID-19 Health Literacy Comics and the Indian Scenario

Reported initially in 2019 with a couple of cases spotted in Wuhan, the COVID-19 pandemic slipped humanity into a dystopian space. Around January 2020, the World Health Organization declared a Public Health Emergency of International Concern. Various measures to taper the spread of the virus, like travel restrictions, social distancing, isolation, quarantine, and lockdowns, were declared by Governments around the world. In the early stages of the COVID-19 pandemic, uncertainty prevailed, demanding clarity on the virus's nature and treatment measures. Health professionals and scientists eventually established vaccination, treatment, and preventive strategies as the pandemic unfolded. Before these developments, non-pharmaceutical interventions and preventive measures were crucial to controlling COVID-19. Creative manipulation of "the art and science of social marketing" strategies in the visual era played a critical role in disseminating public awareness and information literacy on combating the virus (Bhattacharyya *et al.* 7). Specifically in the Indian context during the pre-vaccination and medical intervention phase, health literacy promotion relied on Information Education and Communication (IEC) materials. An analysis of the characteristics and quality of such publicly available COVID-19 IEC materials in India between March and December 2020 proved that "content aesthetics", "readability", and "audience engagement" were the pivotal aspects of such content (Biswas *et al.* 3). A quantitative content analysis within the same study found the characteristics of 265 IEC materials which were found to be used. These included posters, pamphlets, banners, brochures, comic books, and wall art, with 73.96% of these materials directed toward the general public (Biswas *et al.* 3).

Health literacy comics circulated widely during COVID-19, primarily through online platforms like WhatsApp and school authorities. Teachers, parents, or elders often facilitated narration and aided the reading process, making these pictorial pedagogical discourses practical tools for promoting health literacy. Through images, metaphors, and relatable storylines with elements of Indianness, these comics were well-suited for the Indian audience. This study specifically focuses on health literacy comics in India during the pandemic, emphasizing their heightened effectiveness in educating communities on health literacy during this period. Comics, recognized as powerful pedagogical tools, were particularly impactful in conveying health literacy information. According to Venkatesan *et al.*, comics "cultivate scientific temper and rational approaches," contributing to impactful science communication (1-2). This paper delves into the analysis of two health literacy comics released during the pandemic, *Priya's Mask* (2020) and *Nagaraj Strikes: The Attack of the Coronaman* (2020). These comics, seemingly targeted at child audiences, manifest explicit Indianness in their thematic and sartorial construction of superhero/super heroine protagonists and mythical references. The study analyses the gendered viewpoint of the protagonists 'Priya' and 'Nagaraj' and explores how these strategies enhance relatability, fostering a connection with the audience and reclaiming cultural roots.

## MATERIALS AND METHOD

Stuart Hall argues that meaning is something that is thought to be produced/constructed rather than being found to exist (5), and this leads to his concept of the 'practice of representation', where through representations, specific concepts, ideas and emotions get embodied into a symbolic form which later transcends as meanings. Viewed through this lens, comics engage readers actively in the meaning-making process, fostering a dialogic relationship. Comics' shared cultural codes and knowledge frameworks initiate dialogue between producers and consumers. Child audiences, the target consumers, decode the encoded ideologies, including notions of Indianness and gendered superhero construction. Arjun Appadurai contends that consumer revolutions redefine commodification, creating a "peculiar tension between fantasy and nostalgia" (81). Modern consumerism, centred on pleasure rather than leisure, fosters a sense of pleasure through nostalgia and fantasy, representing the present as if it were already past (Appadurai 83). The Indian audience, especially children, becomes the primary target consumer, while parents, teachers, and elders are indirectly targeted. COVID-19 health literacy, focusing on preventive information, strategically cultivates pleasure and tension through the elements of Indianness, drawing on nostalgia and fantasy. This is evident in the mythical roots of superhero/super heroine figures and Corona virus's symbolic portrayal as the







### Albeena Stephen

villain in these comics. Placing Priya against Nagaraj reveals the gendered concepts of masculine versus feminine, which is subtly conveyed through the ideas of hegemonic sexuality and hyper sexuality. Now, contrary to sex, gender is a social construct. Giorgio Agamben brings forth this binary of "zoe and bios" or "bare life and political life" (8), and the Coronavirus reduced society into the subject position of the former in a way. These comics are structured within the typical good versus evil binary plot structure. The villainous virus or the 'bare life' being fought against by society or the 'bios,' and the superhero/super heroine guides this fight. These emergency-era comics shape ideologies through a binary super figure, creating tension between fantasy and nostalgia. The binary distinction lacks fluidity, aligning with Giorgio Agamben's "zoe and bios" (8), as there is a lack of fluidity within the binary distinction of 'bios'. This binary distinction is visible in terms of the emotional composure and approach of these characters, their sartorial composition, and the overall mood of the storyline. All these are subtly conveyed through the nuances of the language of comics. They encourage the reader to follow preventive measures and be a hero/heroine who protects the country from the attack of the evil Corona virus. Thus, these comics became an alternative public sphere for Indian child audiences where they could also be the superheroes/super heroines who fought for the safety of their nation. Aligning with the concept that gender is a construct and Judith Butler's idea that gender is performative and socially constructed, the gendered depiction of the superhero/super heroine is represented through existing social constructs on gender and is further affirmed through the performative act of creating comics. The researcher attempts to decode these via a descriptive qualitative study where these comics are seen as discourses. The method of discourse analysis is aided by the graphic narrative theories of Scott McCloud, the specific focus being on the metaphorical icons that constructs the narrative.

## RESULTS AND DISCUSSIONS

### Nagaraj's Strike and the Coronaman's Attack

Nagaraj, which translates as 'Snake King,' was one of the pioneering and still constant superhero protagonists conceptualised within India by Sanjay Gupta in collaboration with Raj Comics in 1986. This superhero figure is the metaphorical blend, taking inspiration from the mythological 'Ichchhadhari Nag', shapeshifting snakes, and the historical 'Vishmanushya', or venomous humans. This superhero figure is used within the modern context, with distinctive changes within the body figure. Yet, the roots of this character are etched upon old and familiar archetypes and mythological footings. This character's sartorial and physiognomic design has been changing over the years. In one of the earliest comic illustrations by Pratap Mulick, Nagaraj was a relatively thin and dark green superhero. Wearing gold earrings was part of the sartorial aspects of Indian royalty and noblemen. Yet, in style, Nagaraj was similar to Western superheroes with a "figure-hugging costume underneath a pair of pants" (Kaur and Eqbal 94). Instead of snake scales, "snakeskin is alluded to by a pattern of curlicues on his outfit"; however, "the digitised effects on Nagaraj are heavily schematic, with cross-hatching to depict form, replacing curlicue scales on his skin" (Kaur and Eqbal 94). In the current chosen comic, Nagaraj's physique is much more muscular and has an overall modern outlook compared to the initial versions. Wearing a body-fitting suit above, which is worn underpants, the muscular physique and the shade of light green faintly remind of the Western superhero, Hulk.

Thus, Nagaraj is an intermix of the Western and the mythological. Wearing mid-calf boots, around his neck coils snakes, making the audience feel a semblance to Lord Shiva. Compared to the older versions, Nagaraj's current physique with a sharp jawline and much sharper physiognomic aspects forays him onto the audience as a hyper masculine super heroic figure. For easy graphic analysis, the comic is divided into three parts. In the introductory strips, Nagaraj and his snakes fight a thief in Mahanagar. These panels with an almost full-shot view depiction of Nagaraj, along with physiognomic aspects on his face, like the structure of the eyebrows and the lips, convey a confident affirmative feeling that he is powerful enough to tackle anything. This applies to the facial expressions of the fighting snakes, too, having a ferocious, defeating look. On the contrary, the Snake that informs him about the virus seems to have a petrified face. Juxtaposing the confident Nagaraj and the petrified Snake within the same second panel, the might of the superhero is conveyed, and beyond that, their expressions convey a solid masculine figure in a fight against the virus. The second part reveals the Corona virus as the monstrous villain whom they fail to defeat with physical force. There is a transference of physiognomic aspects where Nagaraj and the snakes are petrified.





**Albeena Stephen**

Meanwhile, the second and third panels show the Coronaman's evil face, all set to destroy humanity. In the first panel on this page, where the perplexity and anxiety on Nagraj's and the Snake's faces, the two faces almost look similar, and this can be viewed as a metaphor for the cluelessness of the medical authorities in the initial phase, where there was a bare clue on what precisely this vast spreading new virus was and how to tackle it. The third page depicts the physical combat between Nagraj and the Coronaman. He "spewed his venomous breath", but it did not work, and "even the snakes were ineffective" (Gupta 3). Unlike the other panels, all the panels on this page give a close-up shot of Nagraj's face, further highlighting the physiognomic aspects of him being anxious and worried, contrary to the initial panels, where he seemed confident and composed enough. The fourth panel on the third page says, "...and knocked Nagraj away!" (Gupta 3) and shows his face alone. His slanted lips, wry eyebrows, and dissociated eyes convey this idea of fear towards the novel Corona virus.

With all this, Nagraj realizes that it is not physical force but precautionary preventive measures that would defeat the Coronaman, and the various panels towards the end display WHO guidelines and words like self-quarantine. Nagraj, realizing the importance of preventive measures, shifts the comic into its third part, dedicated to health education. He urges his snake companion to help spread the message in the sixth panel, holding precautionary pamphlets. A central depiction of Nagraj and his snakes distributing pamphlets, inscribed with phrases like "stay home" and "wash hands," forms a symbolic mythical circle. This circular imagery aligns with Hindu beliefs of a timeless, boundless, cyclical, and infinite universe. The final page features an enlarged half-shot of Nagraj in a Vajra Mudra-like pose. The dialogue bubble says, "It's your duty as a citizen to stay home...and help us win this battle! I have saved my city from Corona virus! Now it's your turn to be the hero of your city!" (Gupta 9). The dialogue emphasizes civic duty and heroism, urging readers to stay home and join the battle. This psychological approach validates readers, portraying them as heroes by following the health literacy measures advocated by the superhero. All these panels reveal how the story world is constructed, along with many action sequences, thus creating a more conventional masculine superhero comic feeling within the audience.

**Priya's Shakti and Masking the Virus**

Priya and Sahas are a duo, where Sahas is the tiger, Priya uses a means of commutation that is subtly metaphorical to the goddess Durga, who is seen as a motherly figure within the Indian context, often depicted as a beautiful goddess riding a tiger with many arms and each equipped with a weapon. Goddess Durga is an emblem of a positive force, and with her feminine energy, she protects her devotees from negative, evil forces and safeguards them. Her companion tiger is named "Sahas", which means "courage" in Hindi. The comic panel begins with Priya and Sahas feeling desolate about the absconding humans. Priya is then informed by the waters that "the world is faced with an invisible force- a virus, unlike any other you have met". Like goddess Durga, she dawns upon Sahasa and immediately embarks on her journey to the city to save her people from the evil force of the virus. Her physical appearance reflects her Indianness, and within the selected comic, she is seen wearing a salwar kameez, a traditional Indian garment. She has a gold ornament around her forehead, often metaphorically seen as a third eye on her forehead. In Hindu mythology, this symbol represents enlightenment and spiritual awareness.

On seeing that everyone in the city is wearing a mask, she uses the piece of cloth the water force gives her for her protection to cover her face, and she is seen to be saying, "This mask will help keep the virus out and stop the virus from spreading" (Prakash). The first panel on the third page shows the migrant worker's precarious plight during COVID-19. Within the eighth page, the second-last panel is a low-angle shot of Meena, where her posture and appearance seem like a superhero's. Psychologically, low-angle shots make the subject look powerful. After the ride with Priya and Sahas, Meena is motivated by Priya at the hospital where her mother works. She says in this panel, "And there are still so many people to help! I promise I will be strong for you" (Prakash). Here, Meena is transformed into a powerful subject position. Priya makes her feel that by doing what is bound to rule by restrictive rules, she is a super heroine with her capabilities of following preventive and precautionary measures. There is the introduction of another super heroine figure, Jiya, described by Priya as her friend. She is up "in Chutneyville up North" and "is a teacher and the protector of her city". Jiya's secret identity as a Bhurkha avenger is revealed. Again, the sartorial aspects with which Jiya is depicted create an element of relatability within the Indian audience. In terms



**Albeena Stephen**

of her name and appearance, she resembles an ordinary Indian Muslim woman. Then, the villainous introduction of Baba Kaboom comes in, who resembles a very typical Indian folktale villain. Baba Kaboom says, "I will go myself and spread the virus and make sure Chutneyville is miiiiineeeee!!!" (Prakash). The first panel within the tenth page has a side back shot of Jiya and Priya standing on the terrace with the looming view of the Indian city and saying to each other that knowledge and kindness are the two weapons that would help them in this situation. Here, two regular women, clad in a salwar kameez and a burkha with their feminine energy, are all set to protect the nation by transferring health literacy to their fellow characters in the comic and fellow readers. The comic strip ends with a flying figure of Priya and her magical tiger Sahas amidst many kites, within which many preventive measures are written like "observe social distancing", "wear a mask save lives" (Prakash), and so on. Here, the usage of a feminine force as the superheroine figure transcends the story world into a more emotional one than compared to Nagaraj's world.

**Reading Together the Story-worlds of Nagaraj and Priya**

There is a clear distinction that: Nagaraj is a 'superhero', i.e., a male 'bios', and Priya is a 'superheroine', i.e., a female 'bios' and both fighting against the Coronavirus and encouraging the readers in the 'zoe' stage to be active 'bios' in the fight against COVID-19. However, the binary of the female versus male force makes a difference in how the story world is created. When examined in close quarters, *Nagaraj Strikes: The Attack of the Coronaman* is more happening in a masculine world where any pivotal female characters are barely visible. We see two female figures on the fifth and sixth pages, but they do not have any crucial role within the storyline. Meanwhile, *Priya's Mask* is more female-centric, with many pivotal female characters like Meena, her mother, and Jiya. Whereas, Nagaraj's story world is more action-centric, with five out of the six pages consisting of action sequences, visible through the visual representation within the pages and sound bubbles like "RAWRRR" on page four, the scene where the Corona man is breaking the window panes, the scenes where Nagaraj and Coronaman thrash each other.

These sequences thus instil a sort of adventurous feeling and adrenaline rush for the readers. This constructs the superhero figure Nagaraj as a hyper masculine figure, which is further enunciated via his sartorial, physiognomic and physique design. His muscular physique, body-fitting suit, and assertive, confident physiognomy make him an influential masculine superhero figure capable of defeating anything. Thus, Nagaraj's super heroic existence can be defined as conveying a hyper sexualised masculine force. Meanwhile, Priya's story world is entwined with the story worlds of other female characters like Meena, her mother, and Jiya. This comic seems to have a more emotionally developed storyline. More than conveying a hyper sexually feminine feeling, the story arches of Priya and Jiya convey an emotionally compassionate tale. This is visible on the last page where the antagonist Baba Kaboom post being defeated is taken care of by them. Priya is seen to be saying to Baba Kaboom, "Sahas will take Baba Kaboom to the hospital", and Jiya consoling the anxious Baba Kaboom, petrified at the sight of the tiger by saying, "Don't worry Baba Kaboom. This is Sahas. Priya and Sahas are our friends". In the panel where Sahas embarks on taking Baba Kaboom to the hospital, Jiya says, "I know what you mean, Priya.

We will not survive without compassion for each other". Contrary to the hyper masculine energy conveyed via Nagaraj, it is more of a feeling of compassion and solidarity conveyed here. Interestingly, the fight sequence with the antagonist, Baba Kaboom, is all reduced to a single panel. Further, it is visible that, portraying the Corona virus as a villain, Baba Kaboom, a male figure, and a potentially cruel carrier of the virus, is portrayed as the villain. This can be viewed as the female super heroines fighting against hegemonic masculinity, where what gives them this heroic identity is coupled with their fight against the virus and his evil masculine force. This, however, does not transcend as hyper sexualised femininity as these two female superheroines are portrayed without many ornamental additions like Nagaraj. In his *The Fashion Systems*, Roland Barthes articulates how fashion becomes a cultural sign system via which one can explore how clothing communicates meanings and contributes to identity construction. Unlike Nagaraj in his heroic body-fitting suit and masculine figure, Priya is clad in a regular pink-coloured Salwar Kameez and Jiya in a Burkha. No attempt has been made to construct a hyper sexualised feminine super heroine. Their attires, directly and indirectly, hint at the cultural space that India is on a very subtle level.





Albeena Stephen

## CONCLUSION

India's postcolonial identity spurred a surge in indigenous superhero comics in the 1980s and 1990s, challenging Eurocentric narratives (Kaur 3). Comics like *Amar Chitra Katha* and *Raj Comics* aimed to appreciate postcolonial cultural productions independently (Kaur 3). These indigenous comic productions were discursive responses to "transnational and translational modernity located in the expressive cultures of urban India" (Kaur 3). The selected two comics produced an existing comic series, a pandemic awareness, and a COVID-19 precaution and prevention edition. One advantage of this is that the characters and superheroes are already familiar to the readers. Moreover, even if unfamiliar, the readers would be prompted to decode the roots and history of the characters. Not using a regular Western superhero and using characters like Nagaraj and Priya creates a feeling of strangeness and a feeling of relatability at the same time. The superheroes in these comics, Nagaraj, and Priya, metaphorically resemble Hindu mythological figures. Unlike health literacy comics like *Kids, Vayu & Corona: Who Wins the Fight?* As Appadurai puts forth the idea of commodification, these health literacy comics have been commodified with the agenda of transferring information. This commodification process is embarked on by entwining fantasy and nostalgia. The talking snakes and flying tigers and Priya's and Nagaraj's super heroic powers constitute the fantasy element, and the metaphorical interconnection with Nagaraj, the snake king, and Goddess Durga and the back story behind this character formation comprises the nostalgia element. Most of these comics, having meant for child audiences, in most cases, would be narrated to and aided in the reading process by elders, thus instilling the nostalgia element on two levels, one in the earlier versions of the comics and two in the mythological backdrop.

Therefore, this nostalgia is transferred to the modern child audiences, which thus makes these comics a means to reclaim their roots. However, a gendered notion of superhero figures and the binary between superhero and super heroine is also transferred. Creating a binary of superhero versus super heroine, where the former is hyper masculine, and the latter is feminine and more human-like, can potentially manipulate consumers' perceptions of these comics differently. It may deconstruct the faulty assumptions associated with who exactly a superhero is or lead to a presumption of assuming superheroes have the upper hand over super heroines in terms of their aggression and action sequences. This again leads to the problematisation of the usual archetypes associated with super figures as violent and aggressive in their fight against evil. The winning of hegemony often involves the creation of models of masculinity, which are quite specifically fantasy figures (Connell 184). This is visible within the construction of the fantasy figure of Nagaraj, but the absence is visible within the construction of super heroine figures like Priya and Jiya. Judith Butler believes that individual actions are more habitual than conscious acts. Through their repetitive reenactments, these habitual acts solidify the concept of gender, and this habitually gets coded into the culture. Through the trope of a super heroic figure, the imagery instigated is different.

Coming to Nagaraj, through the character, it is a heroic imagery that is constructed, and through Priya and Jiya, it is a mother imagery that is created. Instead, the portrayal of Nagaraj as a hyper masculine superhero and Priya and Jiya as heroines with more humane emotions and actions again asserts the hegemonic masculinity that rules over the concept of who is a superhero. However, this portrayal within *Priya's Mask* can also be viewed as an attempt to deconstruct this binary of hegemonic masculinity associated with the concept of who a superhero is. Resorting to Indian architectural setups and sartorial aspects makes the comics familiar to the readers and enhances the element of relatability. So, these Indian superheroes are advising the Indian audiences, more per se, children to follow the precautionary measures, via which they get transformed into superheroes who aid in saving their country in times of a medical crisis. The failure of these superheroes to defeat the monstrous virus through force and superhero powers reduces these super heroic figures into mere "zoe". However, at a later point, it is shown how these heroic characters realize that the only means to defeat the villainous virus is via following preventive and precautionary measures. Hence, the message conveyed here is that following these measures makes them, the other characters, and the reader powerful and transcends their bare life versions to an autonomous "bios" version. Thus, the cultural symbols and metaphors used within characterization and the general structuring of these two comics make the context and story readable and relatable to the targeted audience, and the same cultural symbols become a tool via which subtly the



**Albeena Stephen**

audience is made to reclaim their roots. At the same time, these reflect the conditioned binary perception of gender as male vs female.

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## Challenging Beauty Norms: A Discursive Analysis of the New Malayalam Cinema through Social Media Reactions

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### ABSTRACT

This research investigates the evolving beauty standards in the Malayalam film industry through a critical analysis of Nimisha Sajayan's performances in *The Great Indian Kitchen* and *Thondimuthalum Driksakshiyum*. The paper contextualises the pervasive influence of Eurocentric beauty norms in global and Indian cinema. In contrast, Malayalam cinema, particularly the new wave, challenges these norms by showcasing women in more authentic appearances, moving away from excessive makeup and embracing diverse body types. The study aims to explore how Nimisha Sajayan's performances challenge conventional beauty standards. Two key research questions guide the investigation: First, how do Sajayan's characters challenge beauty standards in terms of representing diverse body types and embracing natural appearances? Second, to what extent do audience reactions on social media reflect a changing perspective on non-traditional depictions of female beauty in Malayalam cinema? Employing Critical Discourse Analysis (CDA), the paper unpacks the nuances embedded in language, visuals, and narrative structures in the selected films. Social media comments are systematically collected and analysed to gauge audience reactions. This dynamic platform provides valuable insights into how the audience interprets and responds to the departure from traditional beauty norms in Malayalam cinema. Aligned with the United Nations' Sustainable Development Goals (SDGs), this research contributes to the SDGs by examining the transformative potential within Malayalam cinema, focusing on gender equality and cultural diversity. The study extends beyond academic discourse, prompting reflections on beauty standards within the broader SDG framework, thereby contributing to the global mission of sustainable development and well-being for current and future generations.





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**Keywords:** Beauty Standards, Malayalam Cinema, *Thondimuthalum Driksakshiyum*, *The Great Indian Kitchen*, Social Media Reaction

**INTRODUCTION**

This manuscript delves into the evolving beauty standards within the global and Indian film industries, with a particular focus on the performances of Nimisha Sajayan in *The Great Indian Kitchen* (Dir: Jeo Baby, 2021) and *Thondimuthalum Driksakshiyum* (Dir: Dileesh Pothan, 2017). The film industry has historically adhered to entrenched beauty norms that prioritise conventional aesthetics over authenticity (Chatterjee and Rastogi 2020). This tendency is particularly pronounced in the Indian context, where mainstream films often perpetuate Eurocentric ideals, emphasizing fair skin, slender builds, and specific physical attributes as benchmarks of beauty. Female actors, confined to narrow definitions of beauty, find themselves relegated to supporting roles, often serving as romantic interests with limited depth in the main plot (Sudev 2021). However, recent wave of new-generation Malayalam cinema stands out as a distinctive outlier challenging these entrenched norms (Gopinath and Raj 2015). Films within this genre break away from traditional moulds, presenting women in more natural appearances and embrace a broader spectrum of body types. Nimisha's portrayal in films like *The Great Indian Kitchen* and *Thondimuthalum Driksakshiyum* exemplifies this departure from stereotypical portrayals seen in mainstream Indian cinema. In this transformative cinematic milieu, female characters are afforded more nuanced and compelling roles beyond the limitations of conventional beauty standards. This paper aims to examine the transformative potential of Nimisha's performances by scrutinising how her roles challenge conventional beauty standards in the global and Indian film industries. Concurrently, the research explores the implications of these performances on audience engagement and broader societal beauty norms within the context of Malayalam cinema.

Against the backdrop of contrasting landscapes in mainstream Bollywood and emerging trends in Malayalam cinema (Khadilkar et al. 2022; Gopinath and Raj 2015), this study employs the Critical Discourse Analysis (CDA) approach. CDA serves as a robust methodological framework for unpacking the nuances embedded in language, visuals, and narrative structures within films, allowing an in-depth exploration of how beauty standards are both portrayed and contested (Fairclough 2010). To gauge public reactions and sentiments towards the films and Nimisha's unconventional portrayals, social media comments are systematically collected and analyzed. This approach captures diverse perspectives from a broad spectrum of viewers and provides valuable insights into how audiences interpret and respond to the departure from traditional beauty norms in Malayalam cinema (Henriques and Patnaik 2021). Emphasizing the importance of diverse and authentic portrayals that challenge traditional norms, the study actively contributes to the realization of Sustainable Development Goals (SDGs), specifically those targeting gender equality and the fostering of cultural diversity (THE 17 GOALS | Sustainable Development). Recognizing cinema as a potent cultural influencer, this research aspires to stimulate reflections and discussions on evolving beauty standards within the broader SDG framework, leveraging social media comments as a microcosm of society to discern and amplify their impact.

**Challenging Beauty Standards in Malayalam Cinema**

Nimisha Sajayan's performances in *The Great Indian Kitchen* (Dir: Jeo Baby) and *Thondimuthalum Driksakshiyum* (Dir: Dileesh Pothan) stand as compelling instances of challenging conventional beauty standards in Indian cinema. In the former, Nimisha authentically portrays a newlywed bride, rejecting customary cinematic depictions of radiant brides and, notably, discarding the Mangalsutra to symbolize a departure from traditional gender norms. Her nuanced expressions during domestic labor and emotional conflict deconstruct the stereotypical portrayal of female characters in mainstream Indian cinema (Balraj 2023). To portray her formidable character, she eschews clichéd female portrayals, opting instead for raw emotions complemented by her natural costume and minimal makeup giving justice to the character.





**Aneesunneesa**

Similarly, in *Thondimuthalum Driksakshiyum*, Nimisha's role as a young woman embroiled in a theft incident departs from the expected fair-skinned, innocent victim trope, portraying the character as an ordinary rural woman, emphasising raw emotional depth (Balraj 2023). This challenges the prevalent notion that female characters in distress must adhere to traditional beauty standards to evoke empathy or engagement from the audience (Gopinath and Raj 2015). Nimisha's performances, marked by their authenticity and departure from conventional beauty norms, contribute significantly to the evolving landscape of Malayalam cinema. Her characters in both films embody ordinary daughter-in-law or wife roles, and her decision to forgo makeup and heavy costumes is a testament to the authenticity of her portrayal; it aligns with the evolving trends in Malayalam cinema, where female characters transcend traditional ideals associated with their gender (Balraj 2023). Both these films work as a representation of the newly found trends in Malayalam cinema where female characters and representation go beyond the traditionally set ideals associated with this gender. The contrast between Nimisha's portrayals in Malayalam cinema and prevailing trends in Bollywood highlights the industry-specific resistance to change.

Bollywood, with its adherence to conventional beauty norms, relies standardised portrayals that commodify female beauty for commercial appeal. The resistance or acceptance of changing beauty norms in different film cultures can be attributed to entrenched societal expectations, industry commercialization, and the perpetuation of long-standing stereotypes (Pandian 2021). Bollywood, being a significant player in the Indian film landscape, has been slower to embrace the transformative narrative witnessed in South Indian cinema, especially in Malayalam and Tamil industries. Societal expectations, coupled with a commercial focus on established beauty standards, contribute to the resistance observed in Bollywood. In contrast, the Malayalam film industry's willingness to challenge norms reflects a more progressive stance, driven by a desire to portray authentic characters and narratives that resonate with changing societal values (Sudev 2021; Gopinath and Raj 2015). This contrast in industry approaches lays the groundwork for understanding audience responses on social media following Nimisha's performances, provides insights into the reception of non-traditional beauty depictions in cinema. The systematic collection of comments, primarily sourced from posts made by users on reddit, offered valuable insights into the diverse spectrum of audience reactions. Before delving into the detailed analysis of audience responses, it is essential to consider Nimisha Sajayan's perspective on going without makeup on screen. In a candid reflection, she shared,

"After *Thondimuthalum Driksakshiyum*, I was once approached for a makeover for my look. However, such things never impressed me, unless it is for a character. I believe our flaws make us beautiful, and we should flaunt them enough for people to get used to them and accept them. Even my film characters have been relatable, closer to-life women.....They can comment on my work for sure, but anything beyond that is my life. I have often wondered why anyone should ever take the baggage of others 'expectations of our looks, anyway' (Jayaram 2019). Nimisha's articulation provides a contextual foundation for the subsequent examination of audience responses. Positive comments, lauding her decision to eschew makeup, resonate with the authenticity she endeavours to infuse into her characters. Audiences commend the films for their realistic portrayal of women. Specific references to the emotional impact in scenes devoid of traditional glamorised portrayals underscore the alignment of Nimisha's approach with audience sentiments and the broader discourse surrounding the redefinition of beauty standards in mainstream cinema. Illustratively, a viewer's comment attests to the reception of Nimisha Sajayan's performances:

"I find her really attractive and I think she is a commendable actor. At just 25, she has already undertaken multiple significant roles and received accolades. Her relevance in the Malayalam industry is contingent on the creation of female characters endowed with depth. I believe that as long as the Malayalam industry refrains from emulating the patterns seen in other Indian film industries, where female leads are often relegated to ornamental roles, she will continue to be a prominent figure". (Reddit comment) This perspective underscores the audience's recognition of her worth, emphasizing her exceptional performances rather than the considerations of appearance or attire. Conversely, negative comments often reflected deeply ingrained societal expectations. Criticisms sometimes focused on the perceived deviation from conventional portrayals, revealing the resistance to change in audience expectations. "A heroine's smile should be something that makes us want to bite and eat it," a user posted on Nimisha's social media page (Gayatri). YouTuber Gayatri remarks that our notions of beauty come from caste and class bias, referring to the



**Aneesunneesa**

story of PK Rosy, the first woman actor in Malayalam cinema. Even now, the image acceptable of a woman actor is someone who has an 'eye candy' qualifications (Gayatri 2021). However, it is crucial to note that the prevalence of positive comments outweighed the negative, indicating a significant level of acceptance and appreciation for non-traditional depictions of beauty in cinema. This research underscores cinema's potential as a catalyst for societal transformation, with positive audience reactions contributing to the ongoing discourse on redefining beauty standards (Gogoi 2022). Social media comments, treated as a microcosm of audience reception, has the potential to shape industry practices, influencing filmmakers and encouraging a more inclusive and authentic representation of beauty on screen (Henriques and Patnaik 2021). Positive comments endorsing unconventional beauties challenge ingrained stereotypes and contribute to a more inclusive understanding of beauty. Simultaneously, negative comments shed light on the entrenched resistance to change, illustrating the complexities involved in challenging traditional standards. This contributes to the broader societal shift in defining and accepting diverse standards of beauty (Henriques and Patnaik 2021) hence contributing to the broader SDG goals on gender and cultural diversity.

**CONCLUSION**

The comprehensive analysis of Nimisha Sajayan's performances in *The Great Indian Kitchen* and *Thondimuthalum Driksakshiyum* illuminates a profound departure within Indian cinema from entrenched beauty norms. Sajayan's authentic portrayals courageously challenge and transcend conventional stereotypes that have long prevailed in the industry, offering a compelling alternative and paving the way for more diverse representations. The impact of these films resonates across both cinematic and societal realms. Cinematically, they signify a pronounced departure from the stereotypical portrayals of women, ushering in a new era of authentic and nuanced representations of female characters (Gopinath and Raj 2015). Socially, the positive audience reception indicates a burgeoning openness to embracing diverse and genuine depictions of beauty in cinema. These films, by underscoring the imperative for more inclusive portrayals aligned with contemporary values, possess the transformative potential to shape industry practices and foster a more inclusive film culture (Gogoi 2022). As we contemplate the future, there is ample scope for additional research to delve into the enduring impact of such portrayals on audience perceptions and the evolving standards of societal beauty. A nuanced examination of the role played by other film industries in adopting more diverse representations would further enrich our understanding of the evolving cinematic landscape. The significance of Malayalam cinema in challenging and reshaping established beauty norms is paramount. Reflecting the dynamic shifts in societal values, Malayalam cinema establishes a formidable precedent for more inclusive, genuine, and culturally representative portrayals in the broader film industry (Gopinath and Raj 2015). The profound impact of Nimisha Sajayan's performances and the overwhelmingly positive audience reception underscores the transformative potential of cinema in shaping societal perceptions and cultural narratives. This alignment with the United Nations's Sustainable Development Goals, especially those dedicated to promoting inclusivity and equality in cultural representation (THE 17 GOALS | Sustainable Development), positions this research as a meaningful contribution to the ongoing global discourse on redefining beauty standards and fostering a more diverse, accepting, and culturally rich film culture.

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## Malabar Muslim Women's Reading of Kamala Das' Poem Middle Age

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### ABSTRACT

Malabar is a region situated in the northern side of Kerala state which is famous for its cultural vibrancy and religious harmony. The region was notorious for its illiteracy and ignorance and backwardness in different manifestations of life brought about by the exploitative rule of the colonisers, stringent feudal system and caste discrimination in the society. Colonisation, feudalism and caste discrimination diminished from the mainstream with the attainment of freedom from the colonial shackles. But religious fundamentalism and patriarchy came forward to discriminate the people based on religion and gender. It was the Gulf migration from the Malabar region which brought about multifaceted changes in the society. Their remittance from the gulf changed the social, political and economic background of the region. The women in the society which suffered in the times of colonisation and in the postcolonial times were able to take the fresh breath of freedom and education because of the changes brought about by the gulf migration. But the gulf migration has affected the lives of the middle-aged women in Malabar. The plight of the middle-aged women and the society is well portrayed in the poem *Middle Age* by Kamala Das. The poem explains the pathetic conditions of the middle-aged women in the society. The present paper is an analysis of the condition of Malabar Muslim women in the light of Kamala Das' poem *Middle Age*.

**Keywords:** Colonisation, Muslim, Gulf, Kamala Das, Malabar

### INTRODUCTION

Kamala Das is famous for her confessional poetry, peculiar with simple language and elegance in writing, which discusses the innermost feelings of women's body and psyche. Hailing from the controversial region of Malabar, she spoke about the unexplored realms of literature through her poetry. She was a versatile writer with skills in both English and Malayalam. Most of her poems discussed her personal feelings and emotions which identified her and marked as a representation of the women in the whole region with a global significance. Her identity as a woman

70353



**Mohammed Shafeer**

and as an individual from the controversial region of Malabar is much discussed in many of her literary expressions. Her poetry is peculiar with the exploration of unexplored arenas of discussions regarding the female psychology and identity. Kamala Das's search for ideal love and the resultant disappointment seem to involve the psychological phenomenon of 'the animus' struggling to project the masculine imprint as interpreted by Jung. The attempt to seek in every lover, the perfection of masculine being is destined to end in failure because of the impossibility of realizing the ideal in human form (Chavan 64). The areas of discussions which were considered as private and unexplainable at the mainstream, which relegated the women from the mainstream discussions, were openly discussed in her pieces of literature. She wrote her poems in English language and most of her prose works are in her native language Malayalam. Being a Malayali from the Malabar region, her experiences as a woman is significant because the region and the language has undergone multiple changes along with the changes happening in the lives of the women of the region. The poetic pieces she produced mark her identity as a woman in the mainstream literary arena and also create a representation for the whole community of women in the mainstream discussions and in the literature.

She has accomplished in bringing out the innermost feelings of the women in the society representing herself in her literary creations and created a space for the women along with their challenges in the social, economic and political realms of the mainstream society. "It is a part of the strength of Kamala Das's exploration of love-theme that it also follows her compulsions to articulate and understand the workings of the feminine consciousness" (Kohli 188). Through her poem *Middle Age*, she focuses on an area where most of the writers were unable to focus on the lives of the women in the society. "The poem shows the poet's intense awareness of women having been subjected to all kinds of discrimination: social, cultural, political, (and) sexual" (Chandra, xii). The feminist perspectives focus mainly on the rights of the women and identity creation of the downtrodden gender in the mainstream discussions. Identity creation became the pivot of discussion in the feminist discussions for women empowerment. The discussions revolving around women started from the very birth and existence. The issues began even from the evolution of an individual as a woman from female foeticide and infanticide. Starting from the gender creation of a woman to the range of attainment of puberty and the evolution of menstrual cycle and the evolutionary aspects of a woman became a subject of distinction and suppression of women in the society (Nayar).

But the poem is peculiar with the focus on a specific time period and the life of a woman where she reaches the middle age undergoing multiple changes in her thoughts, feelings, emotions and physic. "Middle age is when your children are no longer/Friends but critics..."(1-2). The changes happening in the body and mind of a middle-aged woman is not much explored in the literary spheres. "Midlife is also a period in the lifespan where pertinent domains, such as mental and physical health undergo significant changes. Physical functioning typically begins to show decline and the onset of chronic illnesses arise, such as high blood pressure, cancer and arthritis" (Lachman). But Kamala Das is brave enough to bring out the life of a middle-aged woman with her problems and issues she faces from the family community and the society. The life of a middle-aged woman is peculiar with the physique which is not more attractive towards the opposite gender and she is considered to be relegated from the mainstream discussions of the family and society because the duties and responsibilities of a woman are considered to be fulfilled when she reaches the middle age. The menopausal changes happening in the woman's body and psychological changes along with the distancing of the husband and the children from her attention and the end of the reproductive scope for the future generation creates confusion in the identity and role of women in the society, community and in the family (Ayranci). Kamala Das concentrates on the role of women in the middle age, along with her condition in the family and society, where she is considered to be an outcast in affairs of the family, community and society. "Mother, You are no longer so young you know"(15-16). The middle-aged woman in the Malabar region never came to a discussion in the social and literary spheres before the publication of the poem, because they were undergoing discrimination and oppression even from the pre-colonial times. The pre-colonial women's condition was peculiar with discrimination based on patriarchy, religious fundamentalism, caste discrimination and feudalism. The arrival of the colonial powers to Malabar was the first intervention from the European powers towards the region though they came as traders to establish trade relationship with the whole region of Indian motherland. The arrival of colonial powers aggravated the discrimination and suppression towards the women and the condition of the women in Malabar was mounted with the problems of colonisation along with





**Mohammed Shafeer**

other challenges existing in the society. The changes happening in the life and mind of the women in the society was not taken into consideration by the mainstream society because of the marginalization existing in the patriarchal male centric casteist, feudal minded, society. Caste discrimination, feudalism, colonial powers, and patriarchy exploited the women of the times along with the crooked minds of religious fundamentalism. The suppression and oppression by the feudal powers and colonial rulers were established in the form of atrocities against the women in the society. Molestation and rape were the usual affairs of the society in the times of colonisation and feudalism.

Women were not able to attain the benefits of education and exposure and they were relegated from the mainstream in the name of gender discrimination and caste discrimination. The identity of women were not a question in the colonial society because the social and political issues in the society were not addressed towards the gender orientation as the challenges of the society was concentrated on the discrimination based on colonialism, feudalism and caste. With the attainment of freedom, the challenges in the form of feudalism, caste discrimination and colonisation came to an end, though caste consciousness existed in the society with all its manifestations. The women in the Malabar region got a slight relief from the challenges and suppression from the part of colonisation, feudalism and caste discrimination. But the problems created by gender discrimination, patriarchy and religious fundamentalism remained in the society with all its pangs to attack the identity and freedom of women in the society. The crooked clergy who utilized and exploited the religious scriptures to control and suppress the women and the society continued their illicit ways and expressions to remove the establishment of identity creation of women in the society as they wanted the women to remain in the inner darker corners of their households, engaged in domestic works and taking care of the family members, children and their husbands. The women and the society were confined to the domestic works and taking care of the family members discarding the basic freedom for education and freedom of expression. Muslim women of Malabar were the main victims of all the challenges existing in the society even from the colonial times to the contemporary society.

Caste atrocities and discrimination based on feudalism and suppression of colonialism came to an end with attainment of freedom in the Malabar region. But the challenges in the form of religious fundamentalism and patriarchy remain in the society of Malabar with all its powers, though changes began to be visible in the political and social atmosphere of the society brought about by the fresh breeze of freedom and the eradication of casteism and feudalism. The victims of religious fundamentalism were basically Malabar rural Muslim women who were not able to enjoy the benefits of education and mainstream exposure. When the challenges of colonisation, feudalism and caste discrimination diminished from the society, the dominant powers became the religious leaders and crooked clergy who wanted to exploit the community and society through all possible means. The clergy realized that education of the women in the society will make them aware of the contemporary society and changes happening in the mainstream society and the religious leaders and clergy kept them away from education and exposure. The ignorance and illiteracy of the women in Malabar helped the religious clergy to aggravate their exploitation and the women of the region were subjected to oppression and exploitation based on the false interpretation of religious scriptures. They were the victims of superstitions and they were not able to break the rules, regulations, norms and dogmas established by the religious authorities and their duties, responsibilities and freedom confined to the inner corners of their domestic households. It was the migration to the Gulf countries from the Malabar region which helped the women of the region to have an access to education and freedom of expression to establish their identity into society, family and community. Migrant youth from Malabar region realized the value of education for women and they encouraged the education of Muslim women. The migrants who were earning for their family and society in the Middle East countries realised the value of global education and language acquisition as a result of their exposure to the globalised world. The religious dogmas and norms established as a result of misinterpretation of the scriptures began to diminish from the mainstream society as the Muslim women from Malabar come came in huge numbers to the mainstream social and political atmosphere to attain knowledge and laurels of education. The educated Muslim women from the region made revolutionary changes in the society as they established their identity of their own challenging the threats established by patriarchy and religious fundamentalism. But the physical and mental changes happening in the lives of women brought about by migration to Gulf countries never came to the mainstream of literary discussions. The Mappila songs of the region represented the aspirations and





**Mohammed Shafeer**

thirst of the Muslim women in the region brought about by the migration of the youth towards the Middle East countries. The poem *Middle Age* by Kamala Das throws light on the life of women in the region and the artistic creation is capable of exploring the life of middle-aged women in the region with their issues and problems created as a result of Gulf migration. The sexual urges dreams and hopes of the woman and the region is not fulfilled because of the separation from their husbands big who are working in the Middle East countries for the sustenance of the family and community. Though migration brought about education and development in the region of Malabar the question of middle-aged Muslim women never came to discussion in the mainstream literary or social arena.

The poem *Middle Age* is capable of discussing the problems and issues faced by the Muslim women in Malabar. It is an excellent example of unearthing the mental and physical aspirations of Malabar Muslim women. The central figure in the poem is portrayed as a middle-aged woman who is ignored by the mainstream society and the family as she is free from the responsibilities of taking care of the children because they have attained a stage to take care of themselves because of their age. As the children are mature with their own identity, the role of the mother in the family diminishes to the margins and the husband is also having little affection and care towards the wife as she is not sexually attractive because of her middle age and menopausal stage. "The age of menopause in Indian women is between 46 to 48 years. Women going through menopause can suffer from hot flushes, weight gain, depression and osteoporosis. The incidence of some female cancers also increases after menopause." ( The Indian Express) Ignored by the mainstream society the middle aged women of Malabar region is suffering from the problem of separation from the husbands and their children, because they are free from the duties and responsibilities of the family and taking care of the children and their husbands. They feel an emptiness of liberation from the duties and responsibilities and the remnants of their toil for the family are not taken into consideration by the society or family. Her identity as a main member of a family who was the pivot of the affairs of the family diminishes to an insignificant member in the family, who has completed the cycle of her evolution (Tamararia).

This confinement to a mere insignificant member of a family along with their physical and mental changes brought about by the age and menopausal stage creates a confusion about her identity and role in the family which is very well expressed in the poem by Kamala Das. Malabar Muslim women in their young age were not able to establish their identity in the mainstream because of the lack of education possibilities and freedom of expression and exposure in the society. They were given only basic education up to secondary level and they will be married at an early age of 13 or 14 and the burden of the family and taking care of the responsibilities of the household and the family will be burdened on them in a tender age. The condition of Malabar Muslim women was in such a state that they were confused in a quagmire condition of immature mind and body but with the burden of responsibilities in taking care of the affairs of the family and the members in the family with a load of domestic works in the family. The girls of the region were having mental and physical problems because of the premature pregnancy and delivery and their life were affected because of the immature and untimely marriage and childbirth. The condition of the women in the region began to change because of the exposure and development brought about by the gulf migration. The remittance from the Gulf region because of the hard toil of the young minds in the region helped the women of the region to get exposure and education though the religious fundamentalist ideas still prevailed in the society and community to draw the women back to the world of illiteracy and ignorance. The women of the region established their identity through the education they attained but the middle age became a challenge for them. According to A.N. Dwivedi: The frequency of love theme may evoke repudiation from nuns and spinsters, and breed boredom in the minds of general readers, but like Sappho in Greek literature, like Elizabeth Barrett Browning in English letters, and like Anne Sexton and Sylvia Plath in modern American poetry, Mrs Das offers us a feast of vivid images of love couched in felicitous language. No doubt, love is her 'forte' in poetry.





Mohammed Shafeer

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## Exploring Sensitive and Dangerous Terrain in *Nirmala* by Munshi Premchand

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### ABSTRACT

Women in our society encounter unique social issues in certain areas, such as gender-based violence or discrimination. Exploring sensitive and potentially dangerous terrain in Indian society as a woman involves additional considerations due to unique cultural, social, and gender dynamics. Women have to be particularly attuned to cultural sensitivities related to gender roles and interactions. One such woman who is not mature enough to handle such things is Nirmala. Poverty and money played a major role in her life which changed the fate of a fifteen-year-old young girl. Gods must be crazy to create a melodramatic future for Nirmala. Munshi Premchand who has a par vision towards the reformation of society designed the plot in such a way to generate awareness among the people in this stereotype society.

**Keywords:** stereotype – isolation – suspect – hypocrisies – poverty

### INTRODUCTION

Terrain refers to a piece of land geographically represented in a map. Only based on the state of land, human settlement can be determined. The type of terrain is centered on the contour interval of the land surface. There are five major terrains like hill, ridge, valley, saddle and depression. Is it possible for human beings to live in all types of land comfortably? They can survive but living comfortably is bit doubtful. But these different features of terrain are natural and needed for a balanced environmental sustainability. Terrain determines the weather pattern, environmental quality, military operations and radioactive processes. When this land becomes sensitive and dangerous, human survival becomes a chance. During extreme weather, heat or cold, floods, fog, tornadoes, lightning, avalanches, rock falls, landslides etc.. people lose their lives. The possibility of living with the family

70358





### Senthilkumari

becomes less or nil. All those unexpected and dangerous situation requires some survival skills. Survival skills give some basic knowledge and interaction with the nature. In present day situation, survival skills help people to save themselves during disaster situation. Survival skills are required not only to escape from natural disaster but also for human made disaster. Not only terrains become sensitive and dangerous even living in a family, to form a happy and peace family – is also difficult in this current situation. It was the time of deprived state of women. Women were considered mere an object of beauty and for household work. Women were treated just as women, a secondary to man, to follow up the words of man, to oblige and serve the man society. Poor families worried about dowry when it comes to marry their girl child. Either the boy is educated or working or idle, dowry was compulsory. Munshi Premchand wanted to change this pathetic situation of the society which makes the country poorer. He brought thoughtful ideas in his novels to create social reforms especially to change the life style of women. All his novels dealt with issues of the society and a clear solution for the same. He wrote something very practical, realistic and natural. *Nirmala* by Premchand depicts the realistic society during the pre-independent India. This novel is branded as a melodramatic fiction because of its sensitive plot.

Premchand desired to bring out a social reform and raise the status of women through the character Nirmala. Nirmala's life style changes because of the poverty, dowry and culture of this static society. The transition from child to wife made her to suffer all the issues in the world. Complication in life started when the arrangements of her wedding started with the Sinha Family. Nirmala felt gloomy. She became serious, lost her bashful smile on her lips. She was not prepared to go out of the family. The very thought that she would be soon sent out with beautiful jewellery, musical band, dance and rejoice made her sad. She wished for a wing to fly from all problems in her life. The first and foremost sensitive incident was the death of her father, the only bread winner. Life became unpredictable for Kalyanai, the mother of Nirmala. Babu Udaybhan, a lawyer with good heart who had helped the less fortunate and poorer was murdered. The fate of Nirmala has changed because of his father's death. As Mary Wollstonecraft said in *A Vindication of the Rights of Woman* that it was time to affect a revolution in female manners - time to restore to them their lost dignity - and make them, as a part of the human species, labour by reforming themselves to reform the world. Kalyani wanted to restore the dignity of the family by marrying Nirmala sooner to someone who was wealthy enough. Kalyani was not able to get just a lakh rupee that could have settled her daughter's life. Bhuvan Mohan Singha was very clear that just a lakh rupee is what he expected from the bride's family to get himself settled in his life. He was not reliant on his own income; instead he wanted something more than his monthly earning which was not affordable by Kalyani. When the mother was terribly sorry for Nirmala, Krishna viewed differently. "... mother it was very fortunate that sister was not married there. How would she have lived with them? This is something to feel happy about..." (33). These words were very true. But how long Nirmala can be kept at home? Half of the marriage arrangements were done. To start all these again was highly impossible for Kalyani. The girl Nirmala was young, beautiful and talented but dowry matters a lot.

Kalyani loved her sons more than daughters, she did not like to spend much on dowry which could make her empty and the sons would be left in dark. Though Moteram brought five different grooms, Kalyani opted to get Nirmala married to a lawyer, widow, with three sons and a widow sister. No dowry was demanded and the lawyers earned three hundred rupees per month which was more sufficient for their happy living. In addition, he has his own house and other owned property. Kalyani thought that the money will give some sophistication since death was unpredictable to humans. Nirmala was not comfortable to be with Munshiji who was of her father's age. He was a person to be respected and not to be slept with. She has love for him. It's a fatherly love and not as a spouse. The elder son Mansaram was sixteen years old: just a year older than Nirmala. The second one Jiyaram was twelve years and the third Siaram was seven years old. Nirmala understood that the place she has entered was sensitive but never thought that it would be dangerous to her and her family members. She was burning and fuming by looking at her enhanced beauty of herself with fine jewellery and gorgeous sari reflected in the mirror. The lawyer learnt the art of making his young wife happy by pouring unlimited love and passion on his wife; surrendering his monthly salary; cosmetics and perfumes; buying her sweets and new jewellery. But nothing amused her. The state of Nirmala reminds us the words of Mary Wollstonecraft: The conduct and manners of women, in fact, evidently prove that their minds are not in a healthy state; for, like the flowers which are planted in too rich a soil, strength state;



**Senthilkumari**

usefulness are sacrificed to beauty; and the flaunting leaves, after having pleased a fastidious eye, fade, disregarded on the stalk, long before the season when they ought to have arrived at maturity. (118, AVRW) Nirmala was not excited or could not find any traces of love for Munshiji. All the gifts and love shown towards her was piercing her heart. "She felt that he did not deserve her beauty and charm" (38). She was a child still who wanted to play with the children. Rukmani Devi was very careful by not letting any of the children near her. She fed poison in the mind of the children and Nirmala was constantly criticized by her. There was a well said saying by Param Pujya Dada Bhagwan in his Tri Mantra, that one should not be suspicious about anyone's conduct, it is very dangerous. How can one see faults in women, when women have given births to great tirthankars? Why should one doubt them? When it is done, there is tremendous liability. But the poison started spreading in the mind of Munshiji when Nirmala told him about learning English from Mansaram. Men always think like men. He noticed sudden change in the behaviour and appearance of his lady and the environment. He even tested her with false promise of arranging tuition to learn English. But his age and experience let him to be patient since the outburst on Nirmala or Mansaram might blow up the whole family. This suspicious behaviour made him to look for immediate arrangement of out hostel for his son.

Mansaram being very sensitive, soft and innocent thought that it was Nirmala who has complained his father about his studies and ill-mannered friends. He could not digest calling him as a "vagabond". This was said by his father and his jiji. He could not take this. It made him very upset and disheartened. He lost his appetite and started longing for his mother. He did not want to have ownership of anything that belonged to the house. He was very much frustrated by the duel behaviour of Nirmala and wanted to go out at the earliest to reduce the burden of his step-mother. Nirmala understood the intention of her husband and avoided Mansaram. At the same time she could not bear the health of her son Mansaram deteriorating day by day. She desired to tell him the truth and console him. But her heart trembled when she thought of seeing him. Munshiji did not stop Mansaram going to school hostel which did not have any basic amenities. Though Nirmala wanted to stop, she remained quite because of her husband. She was frequently blamed by her sister-in-law for sending him out of the house. The liveliness, happiness, peace and joy went along with Mansaram. She felt that it was all her fault. She was guilty since she thought that only because of her arrival, the relationship between son and father broke out. As Jiyaram and Siaram were studying in the same school, she regularly enquired about her elder son's health and studies. When enquired once, "He said my life is a shame, and saying this he started crying." (76) Hearing this Nirmala cried bitterly. Finally it was understood by Mansaram, the reason for sending him to hostel by his father. She was worried much about him than herself since she has nothing to lose or sacrifice. Mansaram, who was a young man of strong values and strong was shrunk by the shameful thought of his father. Nirmala decided to tell him the truth to save the life of Mansaram.

As Anzaldúa said in *Borderlands*, Nirmala determined to have her voice: "Indian, Spanish, white. I will have my serpent's tongue—my woman's voice, my sexual voice, my poet's voice. I will overcome the tradition of silence." Nirmala was waiting for her time to come. In the meantime Mansaram became semiconscious because of high fever. Doctor advised Munshiji to take him home but even in such worse condition Munshiji thought that "there would be many problems, the biggest fear was that at home Nirmala would sit near him all the time and he would not be able to say anything." (89) The stone hearted father took him straight to the hospital rather than his house just because of distrust. Even felt what Nirmala felt when Mansaram left home that the marriage had been the root cause of all the troubles in the family. He questioned himself about the unhappy ending of his second marriage. He justified himself stating that marriage within similar age group will be happier than the mismatched one. Young women would be graceful to young husband not to older one. It was decided and confirmed by vakil without any proof that Nirmala was not loyal to him because of age difference. Whom to be blamed? Munshiji? Nirmala? Mansaram? The long struggle of suspicion came to light with the death of Mansaram. Even the last words of Mansaram with Nirmala did not clear his doubt. When Nirmala came forward to give her every drop of blood shocked and surprised him. Finally he established that she was not an object of enjoyment instead a divine being to be worshipped. As Virginia Woolf mentioned in *To the Lighthouse*, the great day of revelation came. "What is the meaning of life? That was all- a simple question; one that tended to close in on one with years, the great revelation had never come. The great revelation perhaps never did come. Instead, there were little daily miracles, illuminations, matches struck unexpectedly in the dark; here was one." (257) Nirmala's sacrifice became meaningful. It helped to prove the holiness of her existence.





**Senthilkumari**

Munshiji lost interest in everything. His job, health, food and self-care reduced. Sometimes he was not even able to take up a case successfully. Family ran into misery. Munshiji became a worried man. His eyes were filled with shame for marrying a young poor girl followed by the birth of girl baby. He did not dare to look into the eyes of Nirmala. Both money and young wife became distant and did not give him happiness anymore. He felt pity for the poor little creature that has born in his house. Amongst all these miseries Nirmala hugged the little infant with love and wailed for a long time. Munshiji recognized that "A mother's heart is so full of love that the problem and worries of the future do not hold any fear in the mind. She feels a divine power within her which can overcome any problems." (113) Mansaram's death made neighbours and relatives to talk ill about the tortures of step mother. People complained the cause for the death was all the doing of the stepmother. They pretended to show false love and pity for the left over, Jiamam and Siaram. The children also observed the distance between them and their father because of step mother. The extra affection and concern shown on them and their talk about the children's mother started to change the attitude of the boys towards their father. Nirmala remained calm and patience.

She complained her fate for every mishap of the family. She knew well that whatever happens in the house cannot be explained to everyone in the street. She bore all the insults from inside and outside. It was rightly addressed by Burnett in his novella *The Little Princess* When people are insulting you, there is nothing as good for them as not to say a word just to look at them and think. When you will not fly into a passion people know you are stronger than they are, because you are strong enough to hold in your rage, and they are not, and they say stupid things they wished they hadn't said afterward. There's nothing so strong as rage, except what makes you hold it in that's stronger. It's a good thing not to answer your enemies. (78) Everyone became enemies. She was bit relaxed about money and some jewel she had. So far food was not a problem. Jiamam went out of way. His behaviour and activities changed a lot. He became quarrellsome, adamant and rude after the death of Mansaram. Munshiji found very difficult to handle the boy. Constant fight and argument disturbed the family a lot. Nirmala did not show any interest to return from her mother's house. She did not find anything meaningful in her life being a wife and mother of four children. Munshiji's health condition and Jiamam's unbending attitude forced her to return. Jiamam completely blamed his parents that they had poisoned his brother Mansaram. The accusation was unbearable by Munshiji which led to tug of words every day. The unwanted friendship of Jiamam let him to steal the jewellery of his stepmother followed by suicide. The so far quite, kind, loving Nirmala lost her hope in life. She has nothing left to her daughter and son. Survival became difficult with the meager income of Munshiji.

To save extra expense given to servant maid, Siaram was asked to carry out simple work like going to shop before going to school. Siaram was not happy since he was sent again and again to exchange things when the groceries were not up to the mark. Shopkeepers did not welcome the arrival of Siaram because of exchanging business. Nirmala was enforced to do this to save some thing for the future, to reduce the burden of the family. But it went wrong again which made Siaram to run away with a hypocrite ascetic. The whole family was ruined. All simple suggestion and risk taken by Nirmala went wrong and ended in misery. Munshiji and Rukmani cursed the ill fate of Nirmala and the family. As D.H. Lawrence said "A woman has to live her life, or live to repent not having lived it." (345, LCL) Nirmala was not born to live. She lived to repent. The six years of her married life made her to get through all sort of desolation. She proved the words of Ulrich, "Well-behaved women seldom make history." (45) The righteous life of Nirmala went vein and ruined her life to death. This novel is a strong representation of consequences of child marriage and dowry. She missed both personal and social security because of her poverty. All her initiatives to solve the issues of the family failed and she became the sole responsible person for everything. All culpability and fault fell upon her. She developed to be a treat to everyone life in her family. Premchand through this novel highlighted the issue of dowry and child marriage of 1920s. But still it is an ongoing issue which engulfed the life of so many women and their families. Both educated and uneducated demands dowry either in the form of money or in some other way. The gas stove is still blasting. Money cannot make anyone happy at all times. Anything beyond limit is mere waste. There are so many in this world apart from money – love, humanity, peace, sacrifice, justice, kind which cannot be owned by money. People need to understand that, if not life will teach that at the earliest. Child marriage is another issue which has to seriously attend to. Either the girl or a boy needs some maturity to understand the complication of life. A child will be always playful. It could not understand things like





**Senthilkumari**

their parents. Nirmala when married loved to play with the children in the family. She did not realize that she is a mother/stepmother for them. She forgot the traditional relationship. It made her upset and angry. It would be the case of all kids who are married at the young age. In this particular novel, not only Nirmala suffered but also Munshiji. He does not know to handle her. He spent much to match her with artificial cosmetics and hair dye. It was unsuccessful. He ran behind Nirmala to win her heart but it was an utter flop. Because of physical lust he forgot to listen to his sons. As a result they all saw him as their enemies. He started running behind each son one by one. He felt useless about his second marriage to a young girl. It is not only the girl who suffered but also the man and the whole family. Everything collapsed and lost. The relationship was entirely spoiled. No one remained in the family as a family. No one lived for no one. The smooth, fertile and fresh land turned to be sensitive and dangerous land because of culture, society and poverty. If such petty things were attended properly, so many losses can be stopped in families. Through experience one can understand the possibilities of life. Make sure it is not too late to be educated. Unless one learns the survival skill, living becomes difficult. Being a women, one has to be critical and patience to tackle the issues of the family. Even the dangerous terrain will become a suitable land to live when it is mended with care. Literature teaches people to learn the art of survival skills with suitable example from every day today life. Even marriage is also a kind of diaspora for every woman. It is in the hands of each woman to live or survive in the new land. Simple language and simple plot helps people to understand such complex issues of life.

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## Exploring Multi-Layered Marginalisation in Rejina Marandi's novel "Becoming Me"

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### ABSTRACT

This paper aims to explore the life journey of a young Santal girl named *Liya* in the novel *Becoming Me* by Santal writer Rejina Marandi. This exertion attempts to uncover the anguish of the young Santal girl who becomes a victim of a prejudice carried over time because she belongs to an Adivasi tribe. Over time, nothing much has changed in the lives of the Adivasi women workers in terms of employment, wages, equality and living standards. As a Santal writer who is considered a *Baganiaby* the outside world, Marandi considers her book an anecdote of women empowerment where she voices her ideas, thoughts, and experiences in her own way without using much Anglicised versions of names and usages. There is a touch of *Bagania* culture in her tone and language. Rejina Marandi's narrative uncovers the never-ending tales of exploitation in the form of low payment, rape and trafficking of women from the tea gardens. Through her work of art, she exposes the harsh realities of caste discrimination and social hierarchies faced by the Tea Tribes of Assam.

**Keywords:** Double marginalisation, societal marginalisation, spatial marginalisation, North-eastern writers, migration, colonial, indigenous, tea plantations, tea-tribe, trafficking

### INTRODUCTION

Literature acts as a medium through which the decentralized masses can articulate their fragmented thoughts, memories, and feelings. It exposes the oppression and suppression faced by the marginalized and the downtrodden. One such literary work that depicts the tale of the exploitation of Adivasis is *Becoming Me* by Rejina Marandi. The life of the adivasis is one of violence, struggle, and exploitation. The novel brings to light the anecdotes of the distressed tribal workers. Rejina Marandi is a Santal, born and brought up in Gossaigaon, Kokrajhar district, Assam. Her novel is an endeavour to form a collective tribal consciousness based on the several stories that have slipped out of the minds of people or remained suppressed within the Adivasi community. Language was considered a barrier for many of the tribes; "Language should no longer stop us to write .... The history of the Adivasis has always been

70363





**Sebastian Poonolly and Mathew Antony Kattokaran**

written by others – the mainstream historians” (“Release of Becoming me” 2014). The novel marks Rejina Marandi’s debut and a fresh attempt to expose and document a dark corner in the long negation that Adivasis in Assam have suffered. Rejina Maranadi is one who has been identified as an ethnic tea-tribal or *bagania*. Society always looks down on her because of her title, *bagania*. The novel *Becoming Me* is her way of empowering the women in her community whose voice has been silent for many ages or is misinterpreted by someone else. The novel talks about how the tea garden workers are marginalized because of their occupation as well as their physical location. Bell Hooks, in the preface of one of her famous works said that “To be in the margin is to be part of the whole, but outside the main body” (*Feminist Theory from margin to center* 1952). The indigenous people living in colonies are marginalised based on their ethnicity, race and occupation. However, the condition of the women is worse and pathetic in these tea colonies as they have to experience issues of physical and mental abuse. Marginality can be defined as both societal and spatial: Marginality is primarily defined and described by two major conceptual frameworks, i.e., societal and spatial. The societal framework focuses on human dimensions such as demography, religion, culture, social structure (e.g. caste/hierarchy/ class/ethnicity/gender..... Explanation of the spatial dimension of marginality is primarily based on physical location and distance from centres of development, lying at the edge of or poorly integrated into a system. (Gurung and Kollmair, 2007,9)

Thus, individuals experience marginalisation and isolation based on societal and geographical factors. Tea gardens have become locations of modern-day slavery. Being labourers, the *bagania* live in villages inside tea estates established by tea planters. These tea estates are located in interior places and this contributes to their backwardness and exploitation by tea planters. The workers in a way have to live with the basic facilities provided by the tea-planters. *Becoming Me* revolves around the life a young Santal woman named Liya Kisku. Written in the bildungroman style, the novel chronicles Liya’s life from the age of nine till her marriage in the twenty-sixth year. The novel is written in a simple, straightforward English fusing the Santal language, proverbs, metaphors and speech rhythms. She incorporated Santali culture and heritage into her work. The use of Santali dialect in the novel baffles and confuses the non-Santali readers. Maranadi deliberately uses this technique to expose the tension between the tribal and mainstream Assam society. A new voice comes out from the neglected tribal groups. One of the unique elements in the novel is that it does not use the Anglicized version of names, but rather includes the Santal way of addressing people calling the male gender with the suffix-da and female gender with the suffix-di. Chinua Achebe remarked: ‘the writer should aim at fashioning out an English which should be universal at the same time, able to carry his peculiar experience’. The narrative technique of the novel is itself postcolonial. It is a method of subversion and appropriation of forms borrowed from the institutions of the colonizer, and then turning it back against them. She writes for a social purpose and is not art for art’s sake. The dual nature of the author’s existential crisis of ‘being’ within and outside the mainstream linguistic or political discourse, is a marked feature of the work.

*Becoming Me* can be considered as a true piece of North-Eastern literature of India. She became one of the bold woman spokespersons of her community through her literary work. Northeast writers portray the political upheaval and violence affecting the everyday life of common public. The voices that are heard from the North-Eastern part of the country might lack in frequency, but are abundant in personal experiences and undoubtedly contribute to the rich culture of the natives. Northeast literature has for a long time focused on the images of internal resistance and the external conflict and has magnificently linked them together to showcase the extraordinary ability of the inhabitants. Maranadi’s voice brings out the best of culture and tradition of the geographically isolated land. Today, tea is a global product, just like Coca-Cola and MacDonal’d’s. Tea was introduced into the Indian subcontinent as a colonial cash crop and it blurred the regional distinctions, occupying its position as a symbol of unity within ethnic and religious diversities. The tea advertisements that are popular nowadays, portray teagardens as natural parks which resemble a terraced land with a blanket of verdant tea plantations placed on its surface. Thus, these bring into the mind of the onlooker an image of an ecstatic kingdom surrounded by a thick mist of greenery and snow. Despite the wonderful images, the tea-gardens and its workers do not have a fairy tale to tell to the outside world. Instead they have a tale of exploitation, bondage, and poverty. The tea-gardens have become sites of modern-day slavery. In the novel *Becoming Me*, Maranadi says that “The British left India in 1947 [.] but yet the Adivasis of Assam are slaves in the teagardens” (Marandi, 2014, 132).



**Sebastian Poonolly and Mathew Antony Kattokaran**

The strength of tea gardens are the tea-pluckers, of which majority are women, who have mastered the art of plucking the most suitable leaves and buds. The tea companies could never produce their brand-tea products without the tea pluckers' back breaking toil. Plucking tea leaves, is a delicate, labour-intensive and skilled job. However, this work is not recognized as skilled work. Hence, the women workers involved in plucking in the tea gardens are considered as unskilled workers" (Das, 2016, 6). Lack of minimum wages is the first major crisis faced by tea workers, of which eighty-percent are women. These women workers are the ones who are responsible for taking care of their families. In spite of the massive revenue generated from the sales, workers who pick and pack the tea leaves face horrendous conditions and earn far below a subsistence wage. Rejina Maranadi clearly depicts it in her novel: 'Adivasis of Assam have just become an instrument to be used'. There are around 800 to 1000 big tree gardens and thousands of smaller tea gardens in Assam ... The Adivasis are paid a nominal wage of Rs. 94 a day... How they [could] manage their everyday expenses and the children's education. (Marandi, 2014, 132) Indeed, the wage dispute settlements and wage agreements in tea industry of Assam always reflect the supremacy and dominance of the tea industry owners. In one of the news reported by NDTV on the issue of 5000 women workers of Munnar tea estates on strike with a demand to hike their income. The women warn the unions to 'stay out.' They say that the plantation unions have cheated them. They protest that they work just as hard as the men, but still not paid equally. "In a few areas of Indian Subcontinent women are treated as second sex and there is a myth that that women ..... only to do household works" (Priyanka & Sekar, 2022, 80).

The tea labourers are a disadvantaged lot who for decades have been struggling to get reasonable wages. The narrator brings into account the plight of the workers whom she met during a train journey, "Some of our family members, work in tea gardens with very less wages which is not sufficient to run the family and nature has stopped giving us rains" (Marandi, 2014, 153). *Becoming Me* showcases the neglected condition of these tribes, "their women can be dragged naked in the streets of the main society. They can be killed and thrown out from their houses and only be used as slaves to run the tea gardens of Assam" (Marandi, 2014, 132). The entire practice led to a clear case of constrained and forced labour. The labourers, basically being ignorant and poor, were tricked by force and fraud to leave home and to register as labourers under contract in the tea gardens. Once this was done, the labourers were under the total control of the tea garden manager. Far away from the public gaze, they lived virtually as slaves. *Becoming Me* by Rejina Maranadi portrays the tale of exploitation, abuse, rape and, disappearances of women in the tea garden community. "Thus, their actual status turns out to be that of dependent daily wage labourer, who survives in a very damaging ghettoized environment in the colonies" (Das, 2016, 7). Allowing personal and factual, voices to speak in the novel, Maranadi discusses the fetishization of women. Plantation labour is one of the lowest paid works, in which women are highly marginalised. The paper attempts to deconstruct the image of the tea pluckers in tea can advertisements and tea tourism brochures.

It aims to showcase how the image of the exotic tea-plucking women shadows the consumer from the harsh working conditions in tea plantations. The life of women in plantations is miserable. There are many such accounts reported in various articles, "A group of women at one plantation said their supervisors used language with them so vulgar they could not repeat it. Further, the local stereotype outlook of tribal people as promiscuous, figure heavily in taunts" (Das, 2016, 9). Trafficking is another problem which the tea workers, especially children and women face. There are reports of unending disappearances of female workers. The narrator's mother comments: "They have no hope of education. They escape from being the bonded labourers somehow. They move out for more money, and they are misused even outside also" (Maranadi, 2014, 157). CNN Freedom Project has written an article on the trafficking of girls from tea plantations: The Traffickers approach the girls as placement agents ... Police say young girls see placement agencies as a way to escape the cycle, lured by promises of good jobs and a steady income. Instead, they too often find themselves sold as domestic labour and denied wages, or forced to work in the sex industry ("Human trafficking and tea: What's the connection?" 2016) The newspapers are filled with numerous reports of the missing Adivasi girls. The novel depicts how the *dikus* would entice the female workers and offer high paying separate jobs outside the tea gardens: "Leave the girls here, we will give them a better job here. They would get ... six to seven thousand as new joiners and the salaries will slowly increase to fifteen thousand rupees" (Maranadi, 2014, 153). Then another man bargained, "I will pay them fifteen thousand from the beginning... the





### Sebastian Poonolly and Mathew Antony Kattokaran

innocent girls didn't know that the bargaining was for them" (Marandi, 2014, 154). The narrator is moved by the conversation between the sponsors regarding the Adivasi girls. "Trafficking of Adivasi woman is happening because they have no means to survive...There is no value for their life. It's so inhuman to ignore my own dear ones who are victims of human trafficking" (Marandi, 2014, 154). In the website of tea tourism of Darjeeling, the female worker is portrayed as "The colourfully clad tea workers gently plucking the famous two leaves and a bud, humming many a merry tune" ("Tea Tourism in Darjeeling - Sikkim - Dooars"). KailashSatyarthi, founder of the *Bachpan Bachao Andolan* says that "the owners of these international tea estates ... don't pay them minimum wages. The reality is abuse, the reality is a kind of sexual exploitation, the reality is endless slavery" ("The Tea Pickers Sold into Slavery", 2014). One of the attractive features of tea tourism is mimicking the female tea plucker by wearing her attire with the basket. This is one of the cruellest ways of commodifying of the worker. Her pain and labour are reduced to mere acts of fantasy. The female workers in the tea gardens face significant vulnerabilities. It's so strange that the image depicted in the tea advertisements, brochures overshadow the gruesome reality of plantation life. The reality of tea workers is pushed into dark corners of imagination. RejinaMaranadi as social critic conveys a strong message through her novel *Becoming Me* and raises the voice against tribal discrimination in the Indian society. She echoed the real situation of the Tea tribes and the Adivasis, their mentality and reality. In the Indian cultural context, marginality occurs on the basis of caste, class and gender. The postcolonial act of constructing colonies has destroyed the original settlement of the country. Thus, *Becoming Me* by Rejina Maranadi is truly a novel that carries the spirit of women empowerment. It is a reply to the dominating power structures of the society that have always been manipulated by the patriarchal rule. Rejina Maranadi's novel becomes a tool to deconstruct the romanticized version of tea garden women workers.

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## Bridging Education and Community: SCMS Cochin School of Business' Pedagogical Initiatives for Sustainable Development Goal 4 with special focus on Gender

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### ABSTRACT

This paper delves into the strategic initiatives undertaken by SCMS Cochin School of Business, a distinguished institution in Kerala, aimed at fostering quality education and community skill development aligned with Sustainable Development Goal 4 (SDG 4) of the United Nations' 2030 Agenda. The focus is on mapping the institution's pedagogical approaches and community engagement programs designed to ensure inclusive, equitable, and quality education for all while promoting lifelong learning opportunities. Specifically, the paper examines the institution's endeavours in achieving SDG 4.5, which emphasizes Gender Equality and Inclusion. Through a comprehensive analysis, this study highlights the innovative frameworks and practices implemented by SCMS Cochin School of Business to address educational disparities, promote gender equality, and empower diverse communities, contributing significantly to the global pursuit of sustainable and inclusive education.

**Keywords:** - SGD 4, Quality Education, Pedagogical Initiatives, inclusive education, gender equality

### INTRODUCTION

Emphasized in the National Education Policy 2020, higher education is envisioned not just as a pathway to individual employment but as a catalyst for societal transformation. This perspective underscores the pivotal role of quality higher education in cultivating enlightened, socially conscious individuals capable of addressing complex





**Devika and Poornima Narayan**

societal challenges. According to the National Education Policy 9.1.3, “at the societal level, higher education must enable the development of an enlightened, socially conscious, knowledgeable, and skilled nation that can find and implement robust solutions to its own problems. Higher education must form the basis for knowledge creation and innovation thereby contributing to a growing national economy. The purpose of quality higher education is, therefore, more than the creation of greater opportunities for individual employment. It represents the key to more vibrant, socially engaged, cooperative communities and a happier, cohesive, cultured, productive, innovative, progressive, and prosperous nation” (p 33). The policy advocates for substantial revisions in pedagogical approaches and curriculum frameworks in educational institutions to enhance community engagement. It underscores that educational institutions, by imparting values, ethics, and quality education, foster a skilled human resource pivotal for both societal well-being and sustainable business development. The symbiotic relationship between society and businesses, where each supports and benefits the other, hinges significantly on the efficacy of a country’s education system and its educational institutions. Such a paradigm aligns seamlessly with the goals of Sustainable Development Goal 4, specifically targeting Quality Education. Therefore, this study intends to delve into the strategic initiatives undertaken by SCMS Cochin School of Business in Kerala, exploring their pedagogical approaches and community engagement programs. The analysis seeks to shed light on the institution's efforts to promote gender equality, address educational disparities, and contribute significantly to the global pursuit of sustainable and inclusive education, particularly in line with the aspirations of SDG 4.5.

**Objectives**

1. To understand the present scenario in higher education and identifying the gap proposed by NEP 2020.
2. To analyze the role played by educational institutions in enabling community reach and bringing in gender equality.
3. To suggest the initiatives put forward by SCMS Cochin School of Business which will make substantial changes in the outlook of community reach through sustainable education.

**LITERATURE REVIEW**

The literature review of the present study includes National Education Policy 2020 and Sustainable Development Goals Agenda 2030 as the primary references. Within the framework of the National Education Policy (NEP) 2020, the emphasis on quality education and community engagement within higher educational institutions marks a pivotal shift in India's academic landscape. NEP's directives prioritize a multidisciplinary approach, fostering critical thinking, and skill development, all aimed at elevating the standards of education. Moreover, the policy underlines the imperative role of higher education institutions in actively engaging with local communities to address societal needs. By aligning educational programs with community requirements, NEP 2020 not only seeks to enhance the quality of education but also aims to create a symbiotic relationship between academia and society, fostering innovation, societal development, and inclusivity. In "The Engaged University" by John Saltmarsh and Edward Zlotkowski, the authors explore how higher education institutions can actively engage with local communities to address societal issues. They emphasize the importance of partnerships between universities and communities for mutual benefit. Studies by Tania D. Mitchell and Richard O. Jacoby explore how community engagement initiatives in higher education can address gender inequalities. They emphasize the need for inclusive practices that consider the diverse needs of communities and the role of gender-sensitive programs. Research conducted by scholars like Nirmala Tirupattur and Indira J. Parikh has explored participatory learning methods within higher education. These approaches encourage active involvement of students in community projects, fostering empathy, and promoting a deeper understanding of societal issues related to gender, caste, and other forms of discrimination. Studies by educational researchers like Rama Mathew emphasize the significance of culturally relevant pedagogies that consider diverse cultural backgrounds and experiences of students. These pedagogies encourage inclusivity, respect for cultural differences, and sensitivity to social issues.





Devika and Poornima Narayan

## METHODOLOGY

The methodology employed in this study primarily relies on gathering data from secondary sources and the personal observations of the author within the realm of higher education. Abundant and up-to-date information from credible sources pertaining to higher education and academic institutions was readily accessible. The utilization of information and communication technology, particularly the internet, proved immensely valuable in this pursuit. Vital data concerning higher education, continuously updated by key authorities such as UGC, AICTE, NBA, KSHEC and other educational regulatory bodies, was readily available on their respective websites, significantly benefiting this study.

### Present scenario in Higher Education

The landscape of higher education in India, as illuminated by the National Education Policy 2020, stands at a critical juncture, beckoning transformative reforms. At the forefront of this educational evolution lies the formidable challenge of dismantling the entrenched age-old curriculum. A curriculum that, in many instances, remains tethered to outdated courses and subjects, straining under the weight of relevance in our rapidly changing world. Simultaneously, the prevalence of rote learning within the system poses a significant impediment to fostering critical thinking and innovation among students. The ritualistic memorization of information often obstructs a holistic understanding and application of knowledge in real-world scenarios.

Recognizing the need for a radical departure from these archaic practices, the policy underscores the imperative of sustainable education. Going beyond traditional textbooks, sustainable education integrates environmental consciousness and ethical considerations into the curriculum, preparing students for the multifaceted challenges of the future. As a beacon of innovation in pedagogy, the policy advocates for "Learning by Doing" methodologies. This approach, emphasizing hands-on experiences, serves as a catalyst for bringing about novel changes in the education system. A pivotal example of this paradigm shift is found in Social Immersion programs within the management studies curriculum. These programs offer students a unique opportunity to transcend theoretical boundaries and gain real-world insights, bridging the gap between academic knowledge and practical application. In weaving together these threads of change – from reimagining the curriculum to embracing experiential learning – India's higher education system can embark on a journey of transformation, one that fosters adaptability, creativity, and relevance in an ever-evolving global landscape.

### Role of Private Educational Institutions in enabling Community reach and Gender Equity

The educational institutions in India hold a prime position in bridging the gap between education and community to a greater extent. The better financial positions, infrastructure and the greater number of resources have been adequately helping these institutions in carrying out various activities related to Social Immersion and Gender Equity. The relaxed administrative regulations in entering the public domains and underprivileged areas has also contributed to the elevated role of private, standalone and self-financing institutions in India. Higher Educational institutions experience the viability in getting collaborated with various NGOs and nationally and internationally accredited bodies to extend their activities to longer distances, especially in a global world. This helps them to take up the mission and vision of social immersion programmes to a sustainable global world. The Kerala State Higher Education Policy of 2021 reflects a landscape where the prevalence of self-financing and standalone institutions surpasses that of public institutions. This abundance in private educational entities presents a unique opportunity to harness their resources for community outreach activities. Private institutions, often endowed with a diverse faculty possessing rich industry experience, can play a pivotal role in bridging the gap between academia and practical application. Leveraging the expertise of faculty members in community service programs could significantly contribute to local development. Furthermore, the substantial student population enrolled in private institutions offers an extensive cohort for involvement in various community initiatives, ranging from educational support to health and environmental sustainability projects. The policy can encourage private institutions to actively participate in community engagement by setting aside a dedicated portion of their resources or time for these endeavors. The



**Devika and Poornima Narayan**

state can also consider incentivizing and recognizing institutions that excel in community outreach, perhaps through awards, accreditation, or other tangible benefits. The infrastructural superiority of private institutions, often manifested in cutting-edge facilities, can be opened up for community use during non-academic hours. This sharing of facilities could extend to sports complexes, libraries, and research labs, benefitting the broader public. Collaboration between private and public institutions can further enhance the effective utilization of resources, ensuring a synergistic approach to community development. Monitoring and evaluating the impact of these outreach activities should be integral to the policy framework, ensuring that they align with intended goals and contribute positively to the community, thereby fostering a harmonious integration of private higher education institutions into the broader societal fabric.

**SCMS Initiatives to foster Gender Equality**

SCMS Cochin School of Business, through the initiatives of its General Management Department, is making significant strides in promoting SDG 4 and Gender Equity. By fostering inclusivity, providing skill development opportunities, and creating platforms for dialogue, the institution is contributing to a more equitable and sustainable future. These initiatives underscore the commitment of SCMS Cochin School of Business to nurturing socially responsible leaders who can drive positive change in society. In a series of sessions spanning 10 months, the department is undertaking various initiatives to promote Sustainable Development Goal 4 (Quality Education) and Gender Equity

**Commemoration of Days**

To engage and educate the student community, the department organizes a series of sessions commemorating significant days. These sessions include arts and literary competitions that focus on the historical and cultural significance of the day. By incorporating themes related to gender studies, women studies, Dalit studies, LGBTQ challenges, migrant women communities, and marginalized communities in literature, the initiative ensures a comprehensive exploration of diverse perspectives and experiences.

**Memoir Series - Stories of Successful People**

In an effort to inspire and celebrate diversity, the department is conducting a Memoir Series featuring stories of successful individuals who have overcome challenges related to gender, caste, sexual orientation, and socio-economic status. These stories serve as motivational tools for the student body, fostering a sense of inclusivity and empathy.

**Project to Upskill Communication Abilities**

Recognizing the importance of effective communication, the department is conducting a series of four projects aimed at upskilling communication abilities among the canteen and cleaning staff. By providing targeted training, the initiative seeks to empower these staff members and enhance their overall workplace experience.

**Conference on Marginalized Communities and SDGs**

To deepen understanding and engagement, the department is organizing a conference that delves into issues faced by marginalized communities. Subtopics include gender studies, women studies, Dalit studies, LGBTQ challenges, migrant women communities, and cultural inclusivity. This platform facilitates constructive discussions and knowledge sharing, aligning with SDG 4 objectives.

**Management Skills Package for Kudumbashree Units**

In collaboration with Kudumbashree units, the department is developing a management skills package. This package focuses on marketing and accounting skills, empowering women in these units to take on leadership roles and contribute to the economic development of their communities.





**Devika and Poornima Narayan**

## CONCLUSION

The incorporation of gender-sensitive approaches in education is a crucial step towards achieving not only SDG 4 but also contributing to broader societal progress. SCMS Cochin School of Business has recognized the importance of empowering individuals of all genders through education, creating a platform for knowledge exchange and skill development that transcends traditional boundaries. By prioritizing gender inclusivity in their pedagogical strategies, the institution not only prepares students for the challenges of a rapidly changing world but also plays a pivotal role in breaking down societal norms and stereotypes. The ripple effects of such initiatives extend beyond the classroom, impacting communities and contributing to the overall advancement of SDG 5 - Gender Equality.

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## Smart Maritime Conservation: Enhancing MPA Surveillance with IoT, Haversine Method and LoRa Technology

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### ABSTRACT

Underwater Exclusion Zones (UEZs) are assigned areas for the amusement and crossbreeding of marine organisms. Complications linked to the execution of UEZs have endured for numerous years. The involvement of angling undertakings within these zones presents a substantial opportunity to the prolonged viability of aquatic assets. In India, the overseeing bodies rely solely on unmediated visual scrutiny to uncover the entrance of fishing vessels into the UEZs. This manuscript introduces an IoT-based structure devised to scrutinize the arrival of fishing vessels into the UEZ. The structure utilizes the Haversine procedure to compute the interval between the fishing vessel and the UEZ. This interval measurement is then employed to categorize the ship's location condition, which is attainable through a web interface. The analysis employs a LoRa communication component to broadcast topographical details from the fishing vessel to the main station, covering spans of just a few kilo meters. The web interface, amalgamated with the Google Maps API, empowers distant surveillance of fishing vessel entry into the UEZ, delivering an unambiguous and all-encompassing understanding of the scenario.

**Keywords:** Underwater Exclusion Zones (UEZs), Marine Protected Areas (MPAs), Haversine Method, Short for long range (LoRa) Technology, Internet Of Things (IoT), Web Application.





## INTRODUCTION

The ongoing challenges faced by Tamil Nadu fishermen navigating the International Maritime Boundary Line (IMBL) for fishing highlight the need for a solution to prevent accidental border crossings and conflicts with the Sri Lankan navy[1]. Accidental border violations result in human casualties and economic losses for the fishermen. A proposed system aims to address these issues by communicating vessel whereabouts to border security forces, sending alerts to relatives, and providing an incident management application. The automatic alerting system, designed for ease of use, operates based on an intelligent engine and SMS alert system, promising enhanced safety and efficiency for fishermen[4]. The economic activities of shipping, angling, diving, and sailing, though popular, pose environmental threats due to insufficient control and monitoring. Current measures rely heavily on the Vessel Monitoring System (VMS) and Geographical Information System (GIS), limited to registered vessels, posing challenges for law enforcement[3]. Foreign-originating systems, such as VMS and GIS, face usability issues locally, requiring time for adaptation. The study proposes a solution involving Unmanned Aerial Vehicle (UAV) systems and mobile devices equipped with Long Range Radio (LoRa) communication and Light Detection and Range (LIDAR) technology[1]. This approach aims to provide adaptable and cost-effective alternatives for maritime monitoring and control[5], addressing limitations such as high costs, equipment closures, and communication network access issues associated with existing systems[4]. The introduction of UAV systems to oversee coastal and maritime areas, equipped with cameras and GPS gear, offers an alternative to traditional monitoring methods. However, challenges related to restricted communication between the controller and the UAV need to be addressed to prevent loss of control and potential damage[2]. In response, the study proposes the use of mobile devices for data transmission and remote sensing through tracking devices, utilizing LoRa communication and LIDAR technology. This alternative aims to enhance the efficiency and adaptability of maritime monitoring and control equipment, promoting a more robust and responsive solution for various operational challenges, including adverse weather conditions and disrupted communication[2].

### Objectives of the system

The objective of the "Smart Maritime Conservation" initiative is to enhance the surveillance capabilities of Marine Protected Areas (MPAs) through the integration of Internet of Things (IoT), the Haversine method, and LoRa (Long Range) technology. Firstly, the project aims to deploy a network of IoT devices strategically within MPAs to gather real-time data on various environmental parameters such as water quality, temperature, and marine life activity[5]. This data will contribute to a comprehensive understanding of the ecosystem, facilitating informed conservation decisions[6]. Secondly, the implementation of the Haversine method[6], within the project seeks to improve the accuracy of geospatial calculations, particularly in measuring distances between monitoring points and tracking the movement of vessels within the protected areas. This precision is crucial for effective surveillance and enforcement of conservation regulations, ensuring adherence to spatial boundaries and minimizing illegal activities[4]. Thirdly, the utilization of LoRa technology serves as a critical component in establishing a robust communication infrastructure for the IoT devices deployed in the maritime environment. The objective is to enhance the range and reliability of data transmission, overcoming challenges posed by the vast and often remote nature of marine ecosystems[3]. This will enable seamless communication between the deployed sensors and a central monitoring system, ensuring timely and accurate data collection[4].

1. Provide an introduction to Marine Protected Areas (MPAs) and their significance.
2. Develop a system to address the historical rights invoked by Tamil Nadu fishermen, enabling them to fish within the International Maritime Boundary Line (IMBL) without accidental border crossings.
3. Enhance awareness among Tamil Nadu fishermen regarding the IMBL, reducing unintentional border violations and the associated risks of being shot by the Sri Lankan navy.
4. Implement a technology-driven solution to monitor and track the movement of approximately 18,000 boats from Tamil Nadu engaged in fishing along the India-Sri Lanka maritime border.
5. Minimize the economic losses incurred by Tamil Nadu fishermen due to accidental border crossings, promoting sustainable and uninterrupted fishing activities.





**Sivakumar**

6. Improve communication channels between Tamil Nadu fishermen and the proposed system to provide real-time alerts and information about their proximity to the IMBL.
7. Establish a comprehensive alert system within the developed solution to notify fishermen and relevant authorities when there is a potential risk of border infringement.
8. Ensure the safety of human lives by preventing instances of Tamil Nadu fishermen getting shot by the Lankan navy through the effective implementation of the developed system.
9. Facilitate collaboration between Indian and Sri Lankan authorities to share information and coordinate efforts in preventing accidental border violations by fishermen.
10. Enhance the overall economic well-being of Tamil Nadu fishermen by safeguarding their livelihoods through the reduction of incidents leading to loss of lives and economic incomes.
11. Evaluate and iterate on the system's performance regularly, incorporating feedback from fishermen and authorities to continually enhance its effectiveness in preventing border-related issues and ensuring the safety of the fishing community.
12. Highlight the challenges faced in MPA management.
13. Describe the threat posed by fishing activities in MPAs.
14. Mention the reliance on direct visual observation in India for detecting fishing vessel entry.

**LITERATURE SURVEY**

This section provides an overview of existing research related to Smart Maritime Conservation. In the context of enhancing maritime navigation safety for fishermen, several Intelligent Boundary Alert Systems (IBAS) utilizing GPS technology have been proposed. The first system employs an ARM processor to compare the continuously received GPS signals with stored maritime boundary data. When the boat crosses the border, the processor generates an alarm signal transmitted through a wireless sensor network to the base station, benefiting both fishermen and coastal guards [1]. Another GPS-based security system for fisherman auto boats utilizes a microcontroller to compare stored border data with real-time location details. Alarm signals are generated upon border crossings, and the system also incorporates sensors for detecting natural calamities such as icebergs (using ultrasonic sensors) and tsunamis (using MEMS). Additionally, it includes weather forecasting capabilities through temperature and humidity sensors [2]. A surveillance system for fishermen preventing border crossings integrates GPS technology for continuous extraction of boat position data. A microcontroller compares this information with stored border values and alerts fishermen when approaching the border. The system transmits messages to coast guards via RF signals, offering a cost-effective and reliable alternative to GSM modules in maritime communication [3]. The implementation of a Maritime Border Alert System focuses on assisting small-scale fishermen in safe navigation and preventing border violations. The system utilizes GPS for location-based information, comparing real-time data with known border details. The controlling unit makes decisions to alert fishermen and coast guards in case of border proximity [4]. The Arm-Based Fishing Boat Security System employs an ARM processor and GPS technology to ensure safe navigation. When the fishing boat crosses the border limit, the system generates an alarm signal and a voice alert. Using a ZIGBEE module for continuous signal transmission, the system offers maritime security by turning off DC motors if the boat moves further towards the border [5].

**Existing System**

The initial investment of this system to implementing the GPS technology is to provide a secure and reliable tool for fishermen, particularly for maritime navigation purposes. The integration of various systems aims to offer a comprehensive solution to alert fishermen when they are approaching or crossing border limits during their activities at sea[7]. This integrated system not only ensures the safety of fishermen but also facilitates effective navigation for seaway transport. Currently, there are a limited number of existing systems designed to ascertain the current location of boats/ships through the utilization of the GPS System and display their positions on an electronic map. Fishermen employ the GPS72h for identification, a tool specifically designed for navigation at sea. This device offers mariners the quickest and most precise means to navigate, gauge speed, and establish location. The system



**Sivakumar**

enhances safety and efficiency levels, ensuring the secure arrival of the ship at its destination [6]. The precision of position information becomes especially crucial during the vessel's departure from or arrival in port[5]. The core functionality of this system revolves around the seamless integration of GPS and GSM modules. The GPS module serves as a fundamental component for navigation purposes, allowing users to accurately determine the vessel's location and receive real-time distance information from their destination point. This feature is crucial for fishermen to navigate safely and avoid unintentional border crossings, thereby preventing potential risks and ensuring a secure fishing experience[5]. Moreover, the incorporation of GSM technology plays a vital role in monitoring the vessel's activities. This allows for efficient communication and tracking, enabling authorities or relevant stakeholders to keep a close eye on the vessel's movements. In the event of border limit crossings, the system can trigger alerts to notify fishermen promptly, minimizing the likelihood of incidents and enhancing overall safety measures[6]. The modular design of the system is a key feature, ensuring flexibility and adaptability. Users can easily upgrade the system with additional modules to enhance its efficiency or incorporate new functionalities as needed. This scalability ensures that the technology remains relevant and can adapt to evolving requirements, making it a sustainable solution for maritime navigation and fisheries management[4]. In the existing survey, the objectives of this integrated GPS and GSM system are to enhance the safety of fishermen during maritime activities, provide accurate navigation information, and offer a scalable solution that can be easily upgraded to meet evolving needs[7]. This system aims to create a secure and efficient environment for both navigation in seaways and safe fishing practices, contributing to the overall well-being of fishermen and the maritime industry[6].

**Proposed System**

The proposed system incorporates a GPS receiver to determine the boat's current position based on signals received from satellites. It is designed not only for detecting borders between specific countries, such as Sri Lanka and India, but worldwide. The system allows the predefined border, set at a particular layer level, to be stored in the microcontroller's memory. By comparing the current position's longitude and latitude with the predefined values, the microcontroller triggers an alarm to the buzzer, providing immediate notification. Additionally, a message transmitter is utilized to send alerts to the base station, enhancing monitoring capabilities for boats at sea. This comprehensive system serves as an essential tool for both fishermen and coastal guards, ensuring prompt responses to potential border violations and contributing to the safety of fishermen [3]. The system operates with three pre-stored locations strategically positioned a few nautical miles away from the border. At each location, a warning system is activated. The first location triggers a warning buzzer and displays the exact distance between the present location and the border on an LCD display. Simultaneously, there is a 50 percent reduction in boat speed as an initial caution. If the fisherman overlooks the warning and continues towards the third location, the boat's motor comes to a complete stop, and the system sends the location information to the navy control room. The navy can then verify the legitimacy of the fishermen, requiring them to input a randomly generated key to restart the boat. Additionally, the system sends the location information to the fishermen's family members through GSM, providing a multi-layered approach to preventing border violations and ensuring the safety of fishermen [3].

**MATERIALS AND METHOD**

This study introduces an innovative approach to smart monitoring and control through the integration of intelligent systems. The system incorporates Dargino LoRa Shield Wireless, Arduino nano, GPS detector, LIDAR detector, and WiFi Shield module. The primary focus is on detecting foreign objects within a 1-kilometer radius, utilizing the capabilities of the LoRa technology, LIDAR detector, and GPS detector. The proposed prototype aims to enhance maritime surveillance and safety by issuing warnings to authorities if foreign objects are detected[7].

**LoRa Technology and System Components**

The Long Range Radio (LoRa) technology is at the core of this system, supporting IoT applications with communication networks at 433 MHz, 868 MHz, and 915 MHz. The LoRa gateway, connected to the internet and server, serves as a crucial link between LoRa devices and the monitoring infrastructure. The LoRa End-Node[6],



**Sivakumar**

designed as a stand-alone device, features a GPS module, LIDAR module, and solar power supply, providing a comprehensive solution for monitoring boats at sea. The LIDAR module, used for spatial information observation, adopts a unique approach by combining visual object detection with a lightweight model to enhance focus area selection and reduce computational requirements.

**Operation Mechanism**

The LoRa gateway, strategically placed to cover a wide area, connects to a local server or cloud through mobile phone or WiFi network. The GPS sensor captures the location data of the LoRa end-node device, establishing a direct connection to the server through WiFi or cellular modules. The system design incorporates a cloud server for information processing and data visualization, ensuring easy access for enforcement officers [6]. Real-time data transmission allows officers to monitor and track the location of boats or intruders, enabling immediate response in case of emergencies or border violations[7].

**Backtrack Trajectory Evaluation and Prototype Efficiency**

The study evaluates the prototype's communication efficiency using the Easy Dead Reckoning Algorithm (EDR). LoRa serves as the primary communication platform, and the efficiency is assessed through Received Signal Strength Indication (RSSI) testing. The LoRa end-node, equipped with Tx and Rx polarization antennas, moves around the LoRa gateway, sending data every 10 seconds. The EDR algorithm facilitates the evaluation of positions, predicting the next point based on the movement history[5]. Finally, the proposed smart monitoring and control system demonstrates a comprehensive approach to enhance maritime safety, utilizing advanced technologies like LoRa, LIDAR, and GPS. The integration of these components offers real-time monitoring, border detection, and emergency response capabilities, making it a promising solution for maritime surveillance[6].

**Implementation**

Implementation is the stage, which is crucial in the life cycle of the new system designed. The main stage in the implementation is planning, training, system testing. Every developed system must be implemented to fulfill the mode of development. There are many software implementation methods. In this system, direct change over from existing system to computer system is carried. Implementation of IoT technologies, including sensors, actuators, and communication protocols, to enable real-time data collection, analysis, and transmission[4]. This study focuses on implementing smart monitoring and control for marine activities within a 1-kilometer range from a coastal area, specifically tailored for leisure activities. The designed system aims to enhance safety and surveillance for individuals engaged in recreational maritime pursuits. However, it is acknowledged that the coverage area may not be sufficient for deep-sea fishery activities, highlighting a limitation in the current system[6]. To address the limitation and improve the system's applicability, the study proposes future enhancements. One potential improvement is the integration of a communication repeater, which can amplify the communication coverage area. By incorporating a repeater, the system could extend its reach beyond the initial 1-kilometer radius, making it more versatile and suitable for a broader range of maritime activities, including deep-sea fishery[7]. Moreover, the study envisions the system being utilized as a sea buoy to demarcate safe areas specifically designated for leisure activities. This additional functionality aligns with the objective of ensuring safety in recreational maritime endeavors. By designating safe zones through sea buoys, the system can contribute to a more organized and secure environment for leisure activities near the coastal regions. Overall, the study not only addresses the current capabilities and limitations but also outlines potential avenues for future improvements to make the smart monitoring and control system more comprehensive and adaptable[4].

**RESULTS AND DISCUSSION**

The study evaluates the communication efficiency of the Long Range Radio (LoRa) module in a maritime environment, focusing on the relationship between signal-to-noise ratio (SNR) and received signal strength indication (RSSI) values. Figure 8 presents a chart indicating that the efficient communication range for the LoRa



**Sivakumar**

module is not more than 1 kilometer. The observed line for SNR and RSSI values demonstrates a slope that approaches the value of 1000 meters, indicating a decrease in communication efficiency with increasing distance[5]. The decreasing efficiency beyond 1000 meters is attributed to the diminishing energy received by the LoRa end-node from the LoRa gateway as the distance increases. This phenomenon is particularly evident in open and clear spaces with no obstacles along the path of the prototype. The study acknowledges that the efficiency of the LoRa module is highly dependent on the proximity of the end-node to the gateway, emphasizing the impact of environmental factors on communication performance in a maritime setting. While the findings highlight a limitation in the communication range of the LoRa module, the study also suggests that the results may vary in different environmental conditions. The potential for improved results in open and obstacle-free spaces suggests that the efficiency of the LoRa module could be optimized under favorable conditions. Despite the observed limitations[5], understanding the factors influencing communication efficiency is crucial for the practical application of the smart monitoring and control system in maritime environments. Further research and potential enhancements may be explored to address these limitations and improve the overall performance of the LoRa module in maritime communication[6].

**CONCLUSION**

Marine Protected Areas (MPA) are conserved areas for reproduction of marine species. Conflicts in the utilization of MPAs had been a challenge for many years. Fishing activities within the MPAs are real threat for the sustainability of marine resources. In developed countries, direct visual observation of the responsible agencies is the only method to identify the entry of fishing vessels in the MPAs. This paper presents an IoT-based system for monitoring the fishing vessels' entry in the MPA[6].

**Future Scope**

Furthermore, the project aims to develop an integrated platform that consolidates and analyzes the data collected through IoT devices, employing advanced analytics for actionable insights. This platform will empower conservation authorities with the tools needed to make data-driven decisions, optimize resource allocation, and respond swiftly to emerging threats or environmental changes within the MPAs[6]. In conclusion, the overarching objective of the "Smart Maritime Conservation" initiative is to leverage cutting-edge technologies, including IoT, the Haversine method, and LoRa technology, to enhance MPA surveillance capabilities[5]. Through this, the project seeks to contribute to the sustainable management and preservation of marine ecosystems by providing comprehensive, accurate, and real-time data for informed decision-making and effective conservation measures.

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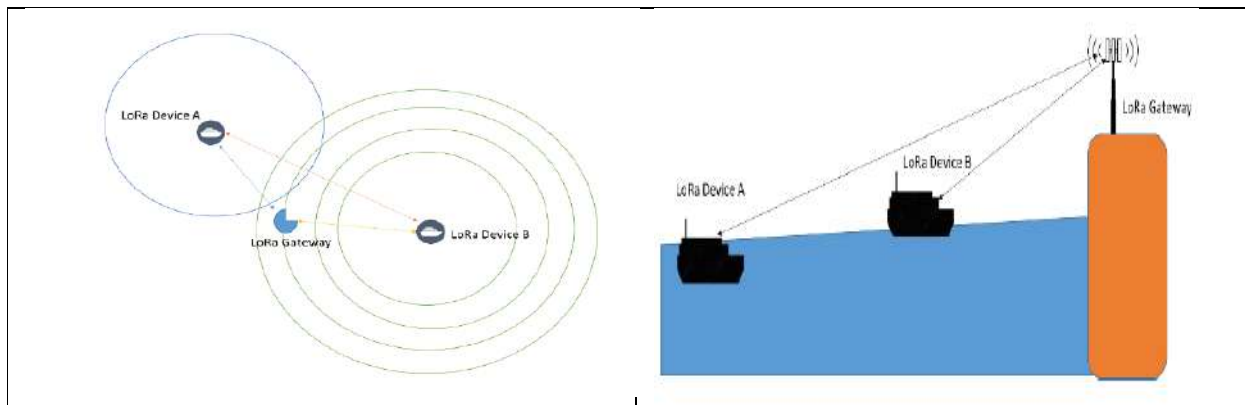


Fig. 1: proposed method to monitor and control marine activity

Fig. 2: Communication between LoRa End-Node and LoRa Gateway

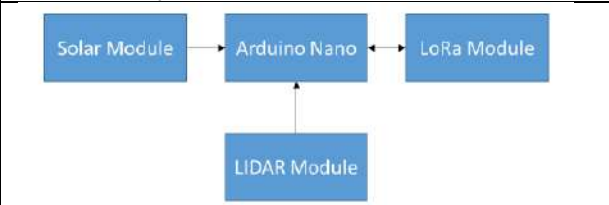
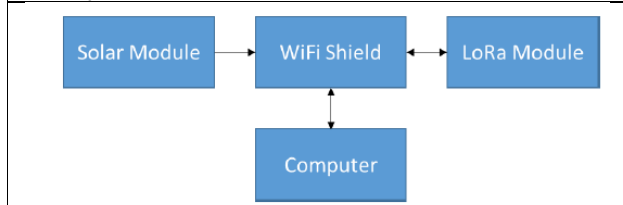


Fig. 3: The block diagram of the proposed LoRa Gateway

Fig. 4: Block diagram of the proposed LoRa End-Node device

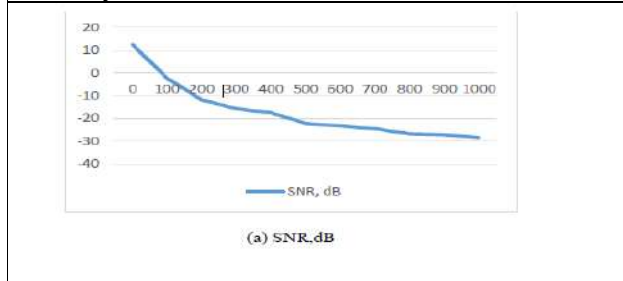


Fig. 5: (a) SNR



Fig. 5: (b) RSSI Chart test results







## Tragedy and Solidarity: Examining the Impact of the 2002 Gujarat Riots on Muslim Women across Rural and Urban Divides

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### ABSTRACT

The 2002 Gujarat riots saw a new era of violence meted out against the Muslims of India. The systematic violence that occurred all over Gujarat for several months created a lot of trauma among the Muslims, women being the worst affected due to mass rapes and burning that were carried out against them in the most barbaric way possible by the Hindu men of Gujarat, backed by the Hindu right-wing organizations and the ruling government. This study aims to understand how the different classes of Muslim Women were affected due to the riots by juxtaposing the experiences of victims from rural districts to those of an urban background. This study takes the accounts of the riots from journalistic reports, and texts by those who witnessed the effects of the violence along with reports and studies that were carried out post-2002. Therefore the outcome of the study is to find links of solidarity between victims of the two social groups if there is any and how it can be improved further towards collective healing.

**Keywords:** Muslim Women, Gujarat Riots, Social Classes, Sexual Violence, Solidarity

## INTRODUCTION

India, a secular nation where the majority of Hindus live alongside the minorities of Muslims, Christians and people belonging to other religious sects and social classes is tainted with the history of communal violence even before independence. The conflicts between the Mughal Empire and the Hindu rulers mark the first instance of communal violence in this region. The Maratha rulers were able to weaken the hold that the Mughal Empire had over the region and by the 19th century the Mughal Empire was wiped out with the help of the British (Gaborieau 7). The British colonisers were also successful in employing the divide-and-rule policy that led to the partition that gave birth to the two new nations: India and Pakistan. The partition forced Muslims to leave for Pakistan while a few of them





**Aasifa Rahmath Hameed**

remained back in secular India. However Hindu right-wing organizations like the Rashtriya Swayam Sevak Sangh also commonly known as the RSS are known for their deep-seated Hindutva ideology that calls for a Hindu *Rashtra* or a Hindu nation by ignoring the secular values that India is famously known for. This ideology has its roots in the early-twentieth-century writings of D.V. Savarkar, a man known as the father of Hindutva, who argued that the Aryans, who settled in India had formed a nation which embodied the Hindu culture, loosely translating that the Indian nation can only belong to the Hindus (Desai 100).

The basis of this ideology allows for the Hindus to hate on the Muslims which has led to the Hindu-Muslim conflicts prevalent all over the country. The RSS backed by the ruling government, the Bharatiya Janata Party painstakingly refers to Muslim settlements as 'Little Pakistan' and shouts slogans like 'Go back to Pakistan' towards Muslims settled in India. Also, the prominent leaders of BJP and RSS have always used dehumanising terms to refer to Muslims in their speeches, inciting hatred in the hearts of the majority general public composed of Hindus. Using narrative techniques that portray Muslims as terrorists who have secret connections with Pakistan, the Hindu right-wing organisations brought out the fiery national spirit among the people to defend their nation from the Muslim invaders. Another narrative technique that is still being employed is to brand Muslims as meat-eating barbarians as the Hindus, especially Brahmins consider themselves pure due to their strict vegetarian diet. This strikes a chord with the Hindus who consider the cow as sacred. Thus we come to an understanding that the rifts between Hindus and Muslims are something that is entrenched within India's history and is something that continues, thriving under the current political climate. The next few sections of this paper will look into the violence meted out against Muslim women during the 2002 Gujarat Pogrom and how it impacted women hailing from different classes.

**Violence against Muslim Women during the 2002 Gujarat riots**

27 February 2002, marks one of the darkest periods in India's history which was just the beginning of the communal riots that engulfed all over Gujarat. What occurred after the Godhra train burning incident was a harrowing tale against the Muslims in Gujarat. The properties of Muslims were looted and burned by large Hindu mobs. Muslim men were ruthlessly murdered, the women were subjected to mass rapes, sexual violence and were burnt without mercy. Even the children were subjected to horrific and unspeakable violence at the hands of angry Hindu mobs who wanted to 'teach the Muslims a lesson' for allegedly carrying out the attack on the Sabarmati Express that saw 59 *karsevaks* die when a coach was set on fire. Even though there has been no concrete evidence pointing out that the deed was done by the Muslims, the politicians ruling the then Gujarat freely spoke against the religious minority and vehemently implied that they were the reason for the deaths. This was carried out without proper investigation or fact-checking before such violently charged statements were made. The government-sanctioned parade of the charred bodies from Godhra to Ahmedabad and the support given to the Vishwa Hindu Parishad, a Hindu right-wing organization to carry out a bandh stirred the majority's sentiments to view the Muslims as their enemy. However, reports point out that the large gatherings of Hindu mobs were mobilized systematically by local political leaders who were supported by the ruling party (Mander 62). It was as if they were given a free ticket to carry out anything they wanted against the innocent Muslims. Witness reports also indicate that the then chief minister Narendra Modi gave out orders to senior police officers to be mere bystanders during the riots so that the Hindus could 'vent their anger' (Mander 20)

Harsh Mander in his book *Between Memory and Forgetting Massacre and the Modi Years in Gujarat* writes about the gut-wrenching incidents that Muslim women were subjected to, especially those who hail from the rural areas. The author dedicated an entire chapter to the experiences undergone by Bilkis Bano who was subjected to gang-rapes while she and her family were trying to escape towards safety while fleeing from their village. The brutal re-telling of the incident recounts how even a newborn child was not spared by the ruthless, merciless men venting out their anger. Mander also writes about the meta-narratives of women recounting horrific violence undergone by their pregnant relatives at the hands of the unruly mob whose foetuses were slaughtered after ripping open the wombs of the mothers (Mander 55). The next section however covers the experiences of upper-class Muslim women during the riots to differentiate experiences of social classes in the face of sexual violence.



**Aasifa Rahmath Hameed****Were the upper-middle-class urban areas spared?**

Before the violent riots of 2002, communal clashes and riots had taken place in Gujarat during the years of 1969 and 1985. Sanjeevini Badigar mentions the story of a Muslim lecturer who was forced to move out of their house during Advani's *rath yatra* in the 1990s after they found a note stuck on their door which threatened them to leave. Therefore Muslims who had the means to move out from riot-stricken areas moved out for their safety. They either moved out of Gujarat or to Muslim localities where they thought they would be safer (Badigar 43). Towns like Anand and regions in western Ahmedabad developed due to these migrations. However, this trend became much stronger after the 2002 riots as the scale of which the crimes were perpetrated was so high. People who had witnessed the previous riots vouch that the 2002 riots were more brutal when compared to the 1969 and 1985 riots (Badigar 44). However, Verstappen notes that safety was not the only factor pushing for migration but also the search for better economic opportunities and social mobility held much importance.

Better academic institutions providing English education were prevalent in Anand where the upper-middle class and elite Muslims migrated to give a better future for their children (Verstappen 67). The town of Anand is situated in the central part of the state and Verstappen also writes about how women were considerably safer in Anand (60). There was only one incident of a stabbing that took place in the town and the locality remained relatively safer amidst the riots, the mobs resorting mostly to loot and pelt stones at Muslim-owned properties (Verstappen 62). Ward Berenschot who did a spatial study of riot-affected areas found out that the comparatively well-off areas of western Ahmedabad remained peaceful, while the violence mainly occurred around poorer localities where textile labourers were housed (222). He also writes about how poorer localities in eastern Ahmedabad were easily susceptible to political mobilization (227). Hence this easily allowed for mobs to be swayed and mobilised to be the perpetrators of violence. Although there are exceptions in understanding who was safe and who was not among the upper-middle-class women, evidence points out that the intensity of the riots affecting those women was considerably less when compared to their rural counterparts.

**Class structures in Muslim ghettos**

The western Ahmedabad region where some of the upper-middle-class Muslims reside is a fairly recent development boasting affluent cityscapes (Laliwala et al. 118). This area on the western side of the Sabarmati River began to develop after independence. It was known as an elite area housing the upper-middle caste Hindus, a few well-to-do Muslims and some Dalit slums (Desai 107). Juhapura is a well-known Muslim ghetto in this area that developed after the upper-middle class Muslims migrated from the Walled City where they lived amongst Hindus. It emerged as a place where Muslims migrated to prevent themselves from becoming victims after seeing the trends of riots before 2002 (Laliwala et al. 110). Even though Juhapura can be termed as a ghetto, it boasts of posh housing societies that thrive alongside slums leading to internal spatial differences within the Muslim community (Laliwala et al. et al. 117). The large-scale migrations of people from different economic backgrounds added to the diversity of class structures as well (Laliwala et al. 111) According to the report by Laliwala et al., Muslim women from the lower classes, those who moved to safer areas after the riots have been very vocal about getting their rights concerning class and gender, affordable housing, skill development, basic infrastructure facilities, women's rights, etc. However, the same report found that there is a failure in providing solidarities between the elite and non-elite Muslims as the women hailing from the upper-middle-class background did not seem very keen to align themselves with the concerns of the lower-class women, to an extent where they feign ignorance about the issues that grapple them.

**CONCLUSION**

When the riots were in full swing, Muslims turned to each other for comfort and solace. Uncharted levels of solidarity were found in relief camps where the Muslims sought refuge from the violence. With the state not giving any hand in re-building the lives of the victims who lost so much due to the riots, it was those Muslims who hailed from affluent and influential backgrounds along with the NGOs providing the victims the means to get back on their feet (Verstappen 62). With the threat of immediate violence dwindling in recent years, there has been a considerable



**Aasifa Rahmath Hameed**

decline in sharing the same social fabric and providing solidarity within communities. As the ghettos of Gujarat possess self-sustaining qualities, they do not hold much importance if one section of women is abandoned or left to fend for themselves. While a few victims openly came out to share their stories of victimhood, some even attaining justice due to these brave acts, Mander notes that a large number of victims opted to stay in silence over the atrocities that happened to them out of fear of retaliatory attacks or for fear of censure from their own families (55). Therefore acts of solidarity shown by those women hailing from the elite classes who have the resources to help these victims, especially by making them seen and heard through empathetic acts might provide the safety net and secure avenues for them to share their stories which could provide the means towards holistic healing or even to attain justice. Doing this will undoubtedly not only improve the status of Muslim women in India but also provide the necessary environment for victims to heal, recuperate and rehabilitate while orienting themselves as citizens of the community and the country, something that the nation failed to do so by not protecting them in the first place.

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## Innovations in Medical Technology: Bridging Nanoscience, Nanotechnology, Nanorobots and Computer Science for Advanced Healthcare Applications

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### ABSTRACT

Nanotechnology & Computer Science-Based Nanorobotic in Medical Field Assistance refers to the integration of nanotechnology and computer science principles in the development and application of tiny robotic devices, often referred to as nanorobots, within the medical field. These nanorobots are designed to perform various medical tasks at the nanoscale level, with precision and efficiency, for diagnostic, therapeutic, or monitoring purposes. This comprehensive research endeavors to unveil the transformative impact of the amalgamation of nanotechnology and computer science in the realm of medical assistance through nanorobotic applications. Delving into the interdisciplinary nature of this cutting-edge field, the study explores the creation and deployment of nanorobots at the intersection of nanotechnology and computer science. These nanorobots are designed to operate within the medical field, undertaking tasks at the nanoscale level, ranging from diagnostics to therapeutic interventions. The research sheds light on the collaborative synergy between nanotechnology and computer science, unleashing a spectrum of innovative medical interventions such as targeted drug delivery, early disease detection, and intricate surgical procedures. This exploration seeks to deepen our understanding of the potential advancements, challenges, and transformative possibilities in the convergence of nanotechnology and computer science for the betterment of healthcare and medical practices. The collaboration between nanotechnology and computer science enables the creation of advanced and highly controlled medical interventions, offering promising possibilities for improving healthcare,





Sivakumar

including targeted drug delivery, minimally invasive surgery, and real-time monitoring of biological processes at the cellular or molecular level.

**Keywords:** Nanotechnology, Computer Science, Nanorobots, Machine Learning (ML), Artificial Intelligence(AI), Internet Of Things (IoT), Web Application.

## INTRODUCTION

"Nanotechnology & Computer Science-Based Nano robotic in Medical Field Assistance" refers to the application of nanotechnology and computer science principles to create and utilize extremely small robotic devices, known as nanorobots, in the field of medicine. These nanorobots are designed to perform various medical tasks at a nanoscale level, offering precise and efficient solutions for diagnostics, therapeutics, and patient care. This interdisciplinary approach harnesses the power of miniaturization and advanced computational capabilities to enhance medical treatments, such as targeted drug delivery, early disease detection, and other innovative medical interventions, ultimately improving patient outcomes and the practice of medicine. Nano robotics represents a cutting-edge frontier where robots operate at incredibly small scales, measuring in billionths of a meter. This field involves the creation of functional materials, devices, and systems by manipulating matter at the nanometer scale, allowing for unprecedented control over molecular gates, switches, and wires. Despite significant advancements in manufacturing precision at larger scales, our capabilities at the molecular level remain relatively crude, prompting the emergence of nanotechnology to address this limitation[1]. Nanorobots, the next evolutionary step in nanomachines, hold great promise in their ability to sense and adapt to environmental stimuli, perform intricate calculations, communicate, and collaborate. Advanced nanorobots could engage in molecular assembly, repair processes, and even partial self-replication. Nanotechnology, defined as the science and application of creating objects smaller than 100 nanometers, explores the extreme concept of bottom-up creation, assembling materials or objects atom by atom. While nanotech processes occur at the nanoscale[2], the resulting materials and objects can manifest on a much larger scale through synergistic nanoscale processes.

### Purpose

Contrary to fears of artificial intelligence threats, many nanorobots, especially those involved in cellular repair, possess limited processing power, with onboard processors capable of around 1000 operations per second. This computing capacity is significantly below human-equivalent computing, making them non-threatening in terms of artificial intelligence concerns[3]. Moreover, medical nanorobots typically require computing capacities several orders of magnitude lower than human equivalents, emphasizing their specialization in specific tasks related to healthcare. The implementation of nanorobotics in medicine, particularly in the realm of robotics, holds immense potential to revolutionize disease treatment and enhance overall human health. By leveraging robots in medical applications, nanorobotics has the capacity to significantly extend human life expectancy, opening up new possibilities for the future of healthcare.

### Scope

The collaboration between nanotechnology and computer science enables the creation of advanced and highly controlled medical interventions, offering promising possibilities for improving healthcare, including targeted drug delivery, minimally invasive surgery, and real-time monitoring of biological processes at the cellular or molecular level.

1. **Bio Nano matrix** Focuses on nanorobots for targeted drug delivery and cancer imaging, using magnetic guidance.
2. **Nanobiotix** Develops nanorobots for cancer therapy, combining nanoparticles and radiation therapy to minimize healthy tissue damage.
3. **Vyriad** Uses nanorobots for oncolytic virotherapy, selectively destroying cancer cells with viruses.





**Sivakumar**

4. **LumaCyte** Develops label-free single-cell analysis technology for cancer diagnosis and treatment monitoring.
5. **Academic Institutions** Universities like Rice University and the University of California, San Diego, are actively involved in nanorobot development for cancer treatment.

**Objectives**

The healthcare revolution is witnessing a significant impact from nanotechnology, with a particular focus on preventive population health management. Nanotechnology addresses issues related to targeted treatment administration by minimizing side effects and optimizing therapeutic effectiveness. Its application extends to the identification, treatment, and gene therapy for various cancers, making nano medicine a promising field within nanorobotics[4]. This innovative technology spans across diverse areas, including vaccine creation, drug delivery, wearable devices, diagnostic and imaging tools, as well as antimicrobial products. Anticipated advancements in nano medicine, with the development of more potent medications, improved gadgets, and early disease detection, are expected to revolutionize healthcare. Nano medicine, crafted through the precise combination of manganese and citrate using nanotechnological methods, has the potential to usher in tailored mechanisms for medication administration, innovative diagnostic approaches, and the creation of nano scale medical devices[5]. The integration of nanoscale technologies with conventional anti-cancer drugs allows for the effective delivery of treatments, even within the brain. The expansive possibilities of nano medicine not only open up substantial market opportunities but also promise to transform entire categories of existing pharmaceuticals, showcasing the transformative impact of nanotechnology in the realm of healthcare.

1. **Product Sales:** Nanobot-based products can be sold directly to customers or businesses.
2. **Subscription or Service Model:** Healthcare providers or research institutions can offer nanobot-based treatments or diagnostics on a subscription basis.
3. **Licensing and Royalties:** Companies can generate revenue by licensing their nanobot technology or IP to other organizations.
4. **Partnerships and Collaborations:** Companies can form partnerships or collaborations for joint research, co-marketing, or technology integration.
5. **Grants and Funding:** Seek funding from government agencies, foundations, or venture capital firms for research and development.
6. **Consultancy and Services:** Offer consultancy services to organizations, providing expertise in nanobot technology.

**LITERATURE SURVEY**

Physicists at the University of Mainz in Germany have engineered the smallest-ever engine, consisting of just one atom. This groundbreaking creation converts energy into movement on an unprecedentedly tiny scale. The atom is confined within a cone of electromagnetic energy, and lasers are employed to heat it up and cool it down, causing the atom to oscillate within the cone like a piston in an engine. Mechanical engineers at Ohio State University have harnessed the principles of DNA origami to design advanced nanoscale mechanical components. This achievement demonstrates that the fundamental design principles applicable to conventional machine components can now be extended to DNA, allowing for the production of sophisticated, controllable components for future nanorobots. Researchers from ETH Zurich and Technion have developed elastic "nano swimmers," specifically polypyrrole (Ppy) nano wires measuring around fifteen micrometers in length and two hundred nanometers in thickness[6]. These nano swimmers can navigate through biological fluid environments at a speed of nearly fifteen micrometers per second. Potential applications include functionalization for drug delivery and magnetic control for targeting cancer cells in the bloodstream. Scientists at the University of Cambridge have engineered an ant-like nano engine capable of exerting a force nearly 100 times greater per unit weight than any existing motor or muscle. These nano-engines, termed "actuating nano transducers" (ANTs), hold potential for developing nano robots small enough to enter living cells for medical applications, offering a new avenue in the fight against diseases.







### Sivakumar

Researchers at the University of Twente and the German University in Cairo have created sperm-inspired micro robots that respond to periodic weak magnetic fields. These micro robots are envisioned for use in advanced micro-manipulation and targeted medical procedures. Engineers at Drexel University have devised a method to utilize electrical fields for aiding microscopic bacteria-powered robots in detecting obstacles in their environment and navigating around them[1]. Possible applications include delivering medication, manipulating stem cells for directed growth, or constructing microstructures. In recent developments, multiple teams of scientists have successfully created nano rockets, high-speed, unmanned versions at the nano scale, by integrating nano particles with biological molecules. The primary objective behind this innovation is to refine the nano rocket to be adaptable for deployment in various environments, particularly with the aim of delivering medicine to specific areas within the human body[2]. This breakthrough holds the potential to revolutionize targeted drug delivery, offering a promising avenue for precise and efficient medical interventions in diverse biological contexts[5].

#### Existing System

The integration of nano science, nanotechnology, nanorobots, and computer science has led to innovative advancements in medical technology, fostering the development of advanced healthcare applications. Several existing systems showcase the collaborative efforts in bridging these fields for enhanced medical solutions. One noteworthy innovation lies in the development of nano scale drug delivery systems. Utilizing nanotechnology, researchers have created nano particles capable of targeted drug delivery, ensuring precise treatment to specific cells or areas within the body. These nano carriers enhance drug efficacy, reduce side effects, and provide a platform for personalized medicine. Additionally, nano sensors integrated into these drug delivery systems enable real-time monitoring, allowing for adaptive and responsive healthcare interventions. Nano robotics has emerged as a transformative technology in medical applications. Nano robots, operating at the nano scale, exhibit the potential for performing intricate tasks within the human body, such as targeted drug delivery, microsurgery, and cellular-level diagnostics. These nano robots are designed to navigate through biological environments, providing a novel approach to medical interventions with unprecedented precision. The synergy between nanotechnology and computer science has led to the development of intelligent diagnostic tools and imaging technologies. Computer-aided diagnostics, powered by machine learning algorithms, analyze vast datasets to enhance disease detection and diagnosis accuracy. Nanoparticle-enhanced imaging techniques[3], incorporating nanoscale contrast agents, offer high-resolution imaging capabilities, facilitating early detection of diseases and abnormalities.

In the realm of regenerative medicine, nanotechnology has played a crucial role in tissue engineering. Nano materials are utilized to create scaffolds that mimic the extracellular matrix, promoting cell adhesion, proliferation, and differentiation. This integration of nano science and tissue engineering holds promise for creating functional artificial organs and repairing damaged tissues. Furthermore, wearable medical devices and sensors leverage advancements in nanotechnology to enhance monitoring and diagnostics. Nano scale materials enable the development of flexible and lightweight sensors that can be integrated into wearable devices for continuous health monitoring. These devices provide valuable real-time data, contributing to preventive healthcare and remote patient monitoring. In summary, the amalgamation of nano science, nanotechnology, nano robots, and computer science has resulted in a spectrum of existing systems that advance medical technology. From targeted drug delivery and nano robotics to intelligent diagnostics and wearable devices, these innovations collectively contribute to the evolution of healthcare towards more personalized, precise, and efficient solutions[6].

#### Drawbacks Of Existing System

**Biocompatibility and Toxicity Concerns** Nano materials used in medical applications may pose challenges in terms of biocompatibility and potential toxicity. Understanding the long-term effects of nano particles on biological systems is crucial to ensure patient safety.

**Ethical and Privacy Concerns** The integration of nano robots and advanced monitoring technologies raises ethical concerns related to privacy and consent. Continuous monitoring and manipulation at the nanoscale may intrude on personal autonomy and privacy, necessitating careful ethical considerations.



**Sivakumar****Technical Challenges**

The development of nano robots and other nano scale devices faces significant technical challenges, including the need for reliable power sources at the nano scale, efficient navigation within complex biological environments, and the design of stable and functional nano materials.

**Regulatory Hurdles**

The regulatory framework for nanotechnology in medicine is still evolving. The approval process for novel medical technologies incorporating nanomaterials or nanorobots may be lengthy and complex, hindering their timely translation from research to clinical applications.

**Cost and Accessibility**

Implementing advanced medical technologies often comes with high costs, making them less accessible in certain healthcare settings. The affordability and widespread availability of nanotechnology-based healthcare solutions remain significant challenges.

**Limited Understanding of Nanotoxicology**

The potential health risks associated with exposure to nanomaterials are not yet fully understood. Nano toxicology, the study of the toxicity of nanomaterials, is a developing field, and the long-term effects of prolonged exposure to nanoscale substances require thorough investigation.

**Integration Challenges**

Integrating nanotechnology with existing medical infrastructure and practices poses challenges. Compatibility issues, training requirements, and the need for interdisciplinary collaboration may slow down the seamless adoption of these technologies.

**Public Perception and Acceptance**

There may be skepticism and apprehension among the public regarding the use of nanotechnology in healthcare. Building trust and addressing concerns about safety, privacy, and potential unintended consequences are crucial for widespread acceptance.

**Environmental Impact**

The disposal of nano materials and waste generated during the manufacturing process can have environmental consequences. The ecological impact of nano particles needs careful consideration to mitigate potential harm.

**Complexity of Data Interpretation**

Advanced diagnostic tools and imaging technologies generate vast amounts of complex data. Analyzing and interpreting this data accurately, while ensuring its relevance in clinical decision-making, poses a challenge that needs to be addressed for the effective implementation of these technologies. Despite these drawbacks, ongoing research and advancements in addressing these challenges hold the promise of mitigating risks and unlocking the full potential of nanotechnology in revolutionizing medical care.

**PROBLEM DISCUSSION**

Nanotechnology plays a pivotal role in expediting diagnostic processes through the use of compact portable devices that can rapidly analyze small samples. This advancement enables almost instantaneous processing and analysis, contributing to the evolution of in vitro diagnostic testing. The incorporation of biosensors and the utilization of nanoparticles, particularly those involving iron oxides and specialty polymers, enhance the imaging capacity while allowing for lower and more effective doses of diagnostic compounds. This breakthrough facilitates early detection of genetic abnormalities, tumors, and a wide range of disease states, thereby significantly impacting the landscape of medical diagnostics. Nanotechnology is making significant strides in various domains, including computer science, where it intersects with several cutting-edge technologies. In the realm of computer science, nanotechnology is contributing to the development of smaller and more efficient components. Nano scale materials and structures are being integrated into computer hardware, enhancing performance and enabling the creation of more powerful and compact devices. This includes the utilization of nano materials in transistors, memory storage, and other essential components, leading to advancements in computational capabilities. Nanorobots, another exciting application of nanotechnology, hold the promise of revolutionizing medical treatments and diagnostics. These miniature robots,



**Sivakumar**

operating at the nanoscale, could be designed for targeted drug delivery, precise surgical procedures, and even cellular-level repairs within the human body. The potential of nano robots extends beyond medicine and may find applications in environmental monitoring and other fields where precise manipulation at the nanoscale is beneficial. In the realm of machine learning (ML) and artificial intelligence (AI), nanotechnology is playing a role in optimizing hardware for accelerated processing. Nanoscale components enable the development of faster and more energy-efficient computing architectures, contributing to the advancement of ML and AI algorithms. Moreover, the synergy between nanotechnology and AI can lead to innovations in the design and optimization of nanodevices[3], paving the way for intelligent systems at the nanoscale. The Internet of Things (IoT) is another area where nanotechnology is making an impact. Nano sensors, for instance, can be embedded in various objects to enable real-time data collection and communication within IoT networks. These nano sensors can provide more precise and sensitive measurements, enhancing the capabilities of IoT devices in applications ranging from smart cities to healthcare[4]. In web applications, nanotechnology's influence may be less direct but still significant. The improved computational capabilities and energy efficiency resulting from nanotechnology advancements can contribute to faster and more responsive web applications. Additionally, nanotechnology's role in developing new materials could lead to innovations in areas such as flexible and transparent displays, which could find applications in web-enabled devices[6]. Overall, the convergence of nanotechnology with computer science, nanorobots, machine learning, artificial intelligence, IoT, and web applications holds great promise for shaping the future of technology, bringing about more powerful, efficient, and innovative solutions across various domains[5]. However, the application of nanomedicine, akin to biotechnology, raises concerns in certain areas, especially regarding safety and privacy. The use of immunoassays is identified as a suitable application due to the robust connectivity between antibodies and antigens, leading to excellent sensitivities[1]. A notable emerging challenge lies in regenerative immune sensors, providing repetitiveness for statistical rigor and semi-continuous monitoring. In the context of cancer, nanomedicine remains an immature subject, necessitating careful evaluation of its potential impact in clinical settings[5].

**Diverse Side Effects**

Cancer treatments like chemotherapy, radiation therapy, immunotherapy, and targeted therapy often lead to side effects such as fatigue, nausea, hair loss, pain, cognitive changes, gastrointestinal problems, and compromised immune function.

**Development of Treatment Resistance**

Cancer cells can become resistant to treatments over time, driven by mechanisms like genetic mutations, altered signaling pathways, or changes in the tumor microenvironment, which can result in treatment failure.

**Toxic Impact on Healthy Cells**

Certain treatments, particularly chemotherapy, may harm healthy cells and organs alongside cancer cells, causing short-term and long-term complications that affect a patient's overall well-being and quality of life.

**Weakened Immune System**

Treatments like chemotherapy and radiation therapy can weaken the immune system, increasing the patient's vulnerability to infections. Infections may lead to treatment delays, interruptions, and necessitate additional medical interventions.

**Financial Burden**

The cost of cancer treatments, encompassing medications, hospital stays, diagnostic tests, and follow-up care, can be substantial. This financial burden can induce stress on patients and their families, potentially limiting their access to care and overall well-being. Furthermore, some treatments can result in long-term effects such as cardiovascular issues, secondary cancers, hormonal imbalances, infertility, or cognitive impairments, even after successful treatment.

**Proposed System**

The healthcare revolution is witnessing a significant impact from nanotechnology, with a particular focus on preventive population health management. Nanotechnology addresses issues related to targeted treatment administration by minimizing side effects and optimizing therapeutic effectiveness. Its application extends to the identification, treatment, and gene therapy for various cancers, making nano medicine a promising field within nano robotics. This innovative technology spans across diverse areas, including vaccine creation, drug delivery, wearable



**Sivakumar**

devices, diagnostic and imaging tools, as well as antimicrobial products. Anticipated advancements in nano medicine, with the development of more potent medications, improved gadgets, and early disease detection, are expected to revolutionize healthcare[3]. Nano medicine, crafted through the precise combination of manganese and citrate using nano technological methods, has the potential to usher in tailored mechanisms for medication administration, innovative diagnostic approaches, and the creation of nano scale medical devices. The integration of nano scale technologies with conventional anti-cancer drugs allows for the effective delivery of treatments, even within the brain. The expansive possibilities of nano medicine not only open up substantial market opportunities but also promise to transform entire categories of existing pharmaceuticals, showcasing the transformative impact of nanotechnology in the realm of healthcare[6].

**Targeted Drug Delivery**

Nanobots are engineered to deliver chemotherapy drugs directly to cancer cells, reducing harm to healthy tissues. They navigate the bloodstream and locate tumors using surface markers or biochemical signals.

**Early Detection Emphasis**

Early cancer detection is promoted through screening programs and healthy lifestyle advocacy, as cancers are more treatable in their early stages.

**Mechanical Disruption of Cancer Cells**

Some nanobots physically disrupt cancer cells by attaching tiny appendages to them, exerting mechanical forces for damage or destruction, offering an alternative to conventional treatments like radiation or chemotherapy.

**Biomarker Detection**

Nanobots with sensors can identify specific biomarkers linked to cancer, offering real-time information on disease progression and facilitating early recurrence detection.

**Immune Response Modulation**

Nanobots can influence the immune response against cancer by stimulating or suppressing specific immune cells, enhancing the body's natural defenses. Additionally, they can carry imaging agents for precise tumor visualization using technologies like MRI, PET, or near-infrared fluorescence imaging.

## MATERIALS AND METHODS

Nanotechnology, a comprehensible concept in theory, encounters challenges in its evolution into a fully functional nanorobot. While considerable progress has been made by scientists, a finalized nanorobot purely based on electromechanical components has not been officially introduced. Many existing nanorobot prototypes exhibit effective functionality but are predominantly biological in nature, deviating from the ultimate goal of creating nanorobots entirely composed of electromechanical elements. Designed as machine counterparts to bacteria, nanorobots operate on the same microscopic scale as bacteria and viruses, interacting with and repelling them[2]. The essential components of an ideal nanorobot include a transporting mechanism, an internal processor, and a fuel unit enabling its functionality. However, the primary challenge lies in developing a suitable fuel unit, as conventional robotic propulsion methods cannot be scaled down to the nanoscale with current technology. Although scientists have managed to reduce robot size to five or six millimeters, this still falls within the macro-robot category. Creating a nanorobot using another nanorobot is deemed the most effective approach, but the initial hurdle lies in initiating the process. Given the complexity and multitude of nano-functions required, it becomes imperative to develop specialized machine tools to expedite the construction and design of nanobots[5].

Nanosensors, essential components in nanotechnology, serve as sensory points conveying information about nanoparticles to the macroscopic world. They find diverse applications, particularly in medicine, and serve as gateways for developing other nano products like nanorobots and nanoscale computer chips[4]. The medicinal use of nanosensors revolves around their ability to accurately identify specific cells or locations in the body by measuring various parameters such as volume, concentration, displacement, speed, velocity, gravitational forces, electrical and magnetic forces, pressure, or temperature changes in cells[6]. In the realm of nanorobotics, specific nano-mechanical devices, including molecular sorting rotors and fins for stability and movement, have been developed. Nanorobot



**Sivakumar**

navigation poses significant challenges, with a focus on external and onboard systems. External navigation involves methods like ultrasonic signals, Magnetic Resonance Imaging (MRI), radioactive dye tracking, X-rays, radio waves, microwaves, or heat detection. Onboard systems, utilizing internal sensors, play a crucial role in navigation, with chemical and spectroscopic sensors enabling pathfinding through the detection of specific chemicals[5]. Power sources for nanorobots are categorized into internal and external options. Internal power sources leverage the patient's body heat, utilizing the Seebeck effect or capacitors, while external power sources include tethered systems or those controlled without a physical tether. Tethered systems require a wire between the nanorobot and the power source, which must navigate through the human body seamlessly. Experimentation in Montreal explores methods to manipulate nanorobots directly or induce electrical currents in closed conducting loops[6]. The procedure for nanorobotics involves manipulating objects at the nanometer scale, functioning at the atomic or molecular level in a process known as molecular manufacturing. Two primary approaches are employed: biochip-based nanorobots for medical applications like surgery and drug delivery, and self-reconfigurable modular robots, also known as Fractal robots, capable of adapting their shape to new circumstances or tasks. These approaches highlight the multifaceted nature and potential applications of nanorobotics in various fields[4].

1. Nanorobots can able to Deliver payloads (Drugs, genes, sensing molecules, etc. )
2. Functions (diagnosis, therapeutic actions, etc)
3. Ability to search for tumor/disease sites
4. Able to receive external power sources (NIR light,ultrasound, magnetic driving force, etc.)
5. Utilize the mediums/blood flow existing in a biological system.

**Implementation**

Implementation is the stage, which is crucial in the life cycle of the new system designed. The implementation phase is starting at process installing software and hardware and requirements. Installation hardware is setting up the PC desktop hardware requirements specification[5]. Understanding nanotechnology is relatively straightforward, but the transition from the overarching concept to the development of nanorobots has proven to be a complex journey. Despite significant advancements, scientists have not yet unveiled a fully functional nanorobot operating solely on mechanical principles. While existing nanobot prototypes excel in certain aspects, they often have biological components. The ultimate objective is to create nanorobots entirely composed of electromechanical components, essentially adapting machine-like characteristics to the microscopic scale[6]. Nanorobots can be considered as machine counterparts to bacteria, functioning on the same scale as bacteria and viruses to interact and counteract them. An ideal nanobot comprises a transporting mechanism, an internal processor, and a fuel unit for functionality. However, the challenge lies in miniaturizing the propulsion system to the nanoscale, as conventional forms of robotic propulsion are not easily scaled down with current technology. Scientists have achieved reductions in robot size, but even a five or six-millimeter robot still qualifies as a macro-robot. Creating nanobots involves a significant hurdle related to fuel units. Since conventional robotic propulsion methods are challenging to shrink to the nanoscale, developing a nanobot becomes a multifaceted task. One effective approach is to use existing nanobots to create new ones. However, the initial challenge lies in starting the process. While humans can perform individual nano-functions, constructing an autonomous robot with thousands of varied applications would be excessively tedious without specialized machine tools. Therefore, the necessity arises to design and create an entire set of specialized tools to expedite the construction and design of nanobots

**Nanotechnology In Computer Science****Quantum Computing as the Future**

As electronic devices reach their physical size limits due to the laws of physics, researchers are looking beyond traditional silicon processors and binary systems. Quantum mechanics, particularly quantum computers, are seen as a practical solution that will bring radical changes to both hardware and software, enabling unprecedented calculations.

**Focus on Quantum-dot Cellular Automata (QCA)**

Memory, a crucial component in circuit design, is a key area of investigation in Quantum-dot Cellular Automata (QCA). Researchers are working to optimize RAM cells in this context.





**Sivakumar****Nanotechnology Enhancing Computers**

The study emphasizes two main aspects of the interaction between computer science and nanotechnology. Firstly, nanotechnology is being used to enhance computer systems and devices, offering new possibilities as traditional silicon technology nears its limits.

**Computer Science's Role in Advancing Nanotechnology**

Secondly, computer science plays a pivotal role in promoting nanotechnology. It aids in the development of computational tools and techniques that are essential for designing new devices and applications in the nanotechnology realm.

**Emerging Computational Nanotechnology**

As silicon technology approaches its capacity, the study highlights the growing significance of computational nanotechnology as a crucial tool for engineering analysis in the creation of novel nano-computers and applications, representing a shift in the future of computing and technology[6].

**Products and Services**

1. **Inhalable Nanobots Product** Our product focuses on delivering nanobots through inhalation. These nanobots are engineered to reach the lungs and navigate through airways to specific locations within the body.
2. **Minimally Invasive Surgery** Nanorobots can be utilized in minimally invasive surgical procedures by navigating through blood vessels and tissues, enabling precise and targeted interventions.
3. **Reduced Invasiveness in Cancer Surgery** This technology has the potential to make cancer surgeries less invasive, resulting in quicker recovery times and fewer complications for patients.
4. **Biomarker Analysis** Nanorobots can be designed to analyze biomarkers found in bodily fluids like blood or urine. These biomarkers offer valuable insights into the presence, progression, and response to cancer treatments.
5. **Improved Personalized Treatment** By offering rapid and accurate biomarker analysis, nanorobots can contribute to enhanced personalized treatment plans for patients, ultimately improving the effectiveness of cancer care.

**Market Opportunity & Target Market**

1. **Pharmaceutical and Biotechnology Companies** These companies can invest in nanorobot-based therapies, partnering with nanotechnology firms to advance technology.
2. **Healthcare Providers and Hospitals** Nanorobots can be adopted for cancer treatment, potentially reducing invasiveness and improving patient outcomes.
3. **Research Institutions and Academia** Collaboration with industry partners is essential for validating nanorobot-based therapies.
4. **Regulatory Authorities** Regulatory bodies like the FDA and EMA will evaluate nanorobot therapies' safety and efficacy.
5. **Patients and Healthcare Consumers** Nanorobots have the potential to enhance cancer treatment, reducing side effects and improving quality of life.
6. **Surgical Applications** Nanorobots can improve surgical procedures, including targeted tissue removal and minimally invasive interventions.

**RESULTS AND DISCUSSION**

The study exploring the integration of nanoscience, nanotechnology, nanorobots, and computer science in medical technology yielded promising results across various domains. Nanosensors, employing biological, chemical, or surgical sensory points, demonstrated substantial potential for conveying information about nanoparticles to the macroscopic world. Their application in medicine, particularly for targeted drug delivery, showcased advancements in precision and adaptability. The development of nanorobots, operating at the nanoscale, exhibited remarkable capabilities for tasks such as targeted drug delivery, microsurgery, and cellular-level diagnostics. These nanorobots showcased potential solutions for navigating through biological environments, offering a new dimension in medical





**Sivakumar**

interventions with unprecedented precision[2]. The integration of nanotechnology and computer science in diagnostic tools and imaging technologies emerged as a transformative aspect of this study. Computer-aided diagnostics, powered by machine learning algorithms, demonstrated enhanced disease detection and diagnosis accuracy through the analysis of extensive datasets. Nanoparticle-enhanced imaging techniques, incorporating nanoscale contrast agents, offered high-resolution imaging capabilities, facilitating early detection of diseases and abnormalities. The study emphasized the need for addressing ethical concerns associated with continuous monitoring and manipulation at the nanoscale[5], highlighting the importance of privacy and consent in the implementation of these advanced technologies. The examination of nanorobot navigation systems presented a critical aspect of the study. External navigation systems, utilizing methods such as ultrasonic signals, Magnetic Resonance Imaging (MRI), and other detection techniques, showcased potential pathways for guiding nanorobots to their intended destinations within the human body. Onboard systems, incorporating internal sensors, played a pivotal role in navigation, with chemical and spectroscopic sensors allowing nanorobots to follow specific chemical trails, enhancing their pathfinding abilities. The study underscored the importance of addressing technical challenges[5], including power sources at the nanoscale, efficient navigation, and the design of stable nanomaterials for successful implementation in healthcare applications[6].

**CONCLUSION**

Nano medicine holds the promise of eradicating prevalent diseases from the upcoming century, alleviating medical pain and suffering, and enhancing human capabilities, particularly mental abilities[1]. The potential of nanotechnology is exemplified by the concept of a nanostructure data storage device, occupying a volume about the size of a human liver cell and smaller than a typical neuron. This device, measuring approximately 8,000 cubic microns, could store an amount of information equivalent to the entire Library of Congress. Implanting such a device in the human brain, coupled with suitable interface mechanisms, could enable rapid access to vast amounts of information, revolutionizing cognitive capabilities. Teams worldwide are actively engaged in developing the first practical medical nanorobot, with prototypes ranging from a millimeter to two centimeters in size. However, these robots are still in the testing phase and have not been used on humans. The deployment of nanorobots in the medical market is likely several years away, as current micro robots are merely prototypes without the capability to perform actual medical tasks. While these tiny robots hold immense potential, they are not yet ready for practical medical applications[5]. In conclusion, the results and discussion underscored the significant strides made in medical technology through the convergence of nanoscience, nanotechnology, nano robots, and computer science. The study demonstrated the potential of nano sensors and nano robots in precise drug delivery and intricate medical interventions, while the integration with computer science offered intelligent diagnostic tools and advanced imaging technologies. The discussion emphasized the ethical considerations, technical challenges, and the need for further research to optimize the implementation of these innovations in healthcare applications[6]. Overall, the study contributes to the evolving landscape of medical technology, paving the way for more personalized, efficient, and advanced healthcare solutions.

**Future Scope**

Nanorobotics emerges as a pivotal field in technology and robotics, focusing on creating machines or robots at the nanometer scale. Specifically, nanorobotics involves designing and constructing nanorobots devices made of nanoscale or molecular components. The application of nanorobots in medical procedures, such as heart bypass surgery, is highlighted in a seminar report. Traditional heart bypass surgery poses risks, and while highly trained specialists minimize dangers, nanorobots offer a safer, faster, and more effective alternative[4]. The future outlook for nanorobots in medicine is revolutionary. Envisioned applications include the treatment of conditions like heart disease and cancer using robots at a scale much smaller than current technologies. Nanorobots could operate individually or in teams to eradicate diseases and address various health conditions. Another potential future application involves the deployment of semiautonomous nanorobots that patrol the human body, responding to emerging issues. Unlike acute treatment methods, these nanorobots could remain within the patient's body permanently[6]. Beyond medical treatment, nanorobot technology might be applied to re-engineer the human body,



**Sivakumar**

making it resistant to diseases, enhancing strength, and even improving intelligence. Dr. Richard Thompson emphasizes the importance of ethical discussions surrounding nanotechnology, urging communication among communities, medical organizations, and governments while the industry is still in its early stages. The possibilities presented by nanotechnology, including the idea of microscopic robots performing healing functions within our bodies, highlight the transformative potential of this emerging field[5]. These microscopic machines can remove plaque from internal artery walls without invasive surgical procedures, presenting an efficient method for plaque removal. Although the technology and its application to the human body are in preliminary stages, the potential for putting these ideas into action is on the horizon, promising transformative advancements in healthcare within the foreseeable future[6].

1. **Continued Research** Ongoing research is crucial to enhance nanorobot design, functionality, biocompatibility, and safety.
2. **Funding and Investment** Adequate funding from government agencies, private investors, and venture capital firms is vital for development.
3. **Clinical Trials** Well-designed clinical trials are necessary to establish safety and efficacy, requiring collaboration between researchers, healthcare institutions, and pharmaceutical companies.
4. **Scalable Manufacturing** Developing scalable nanorobot manufacturing processes to meet healthcare demand is essential.
5. **Efficient Production** Establishing cost-effective production methods for widespread availability and affordability of nanorobot-based treatments.

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Sivakumar

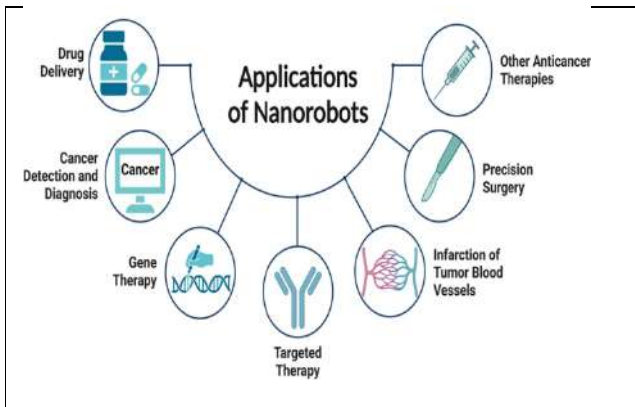


Fig 1: Applications Of Nanorobots In Medical Domain

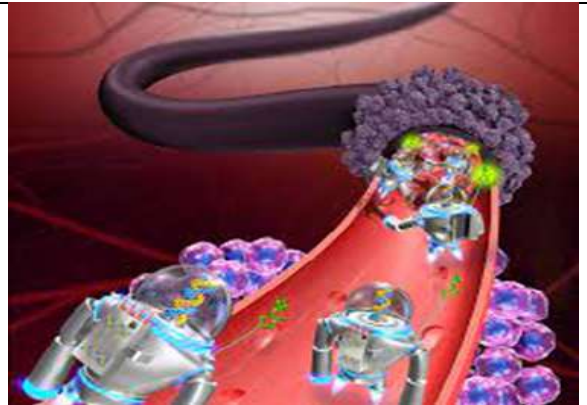


Fig 2: Cancer Tumors Killed By Nanorobots(Internal)

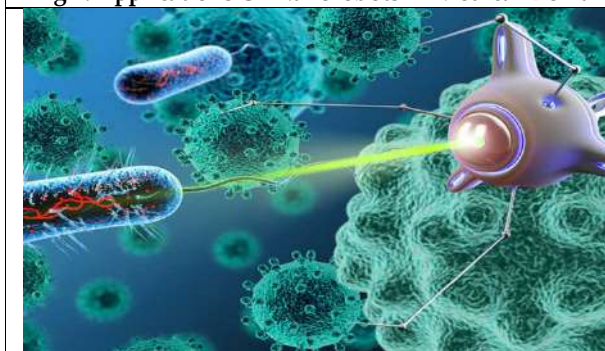


Fig 3: Cancer Tumors Killed By Nanorobots(External)

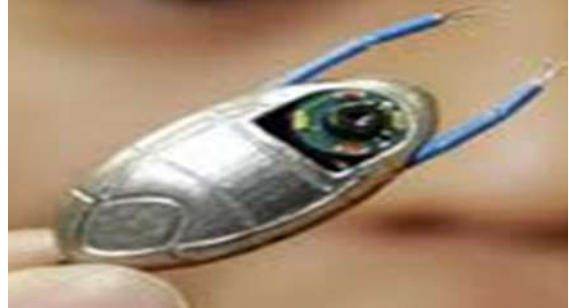


Fig 4: Physical Model of Nanorobot At Present

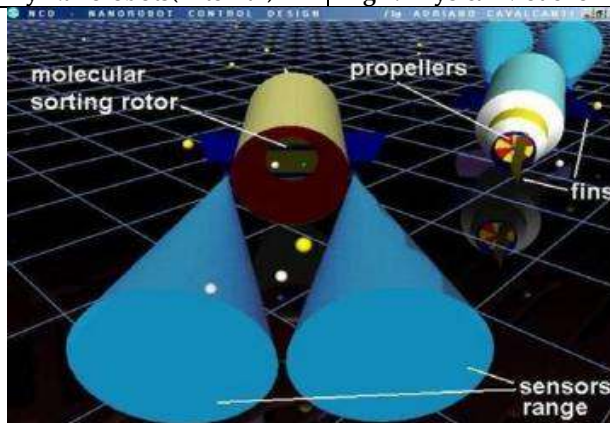


Fig 5: Nanorobot Design





## The Power Divide: Tracing the Roots of Segregation and Exclusion of Transgender people in India

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### ABSTRACT

As mentioned in the Kama Sutra, people with tritiya-prakriti have an antique recorded history. During the Mughal period, transgender people played a significant role in empire-making due to their political knowledge, power, and loyalty. They also exhibited a unique quality of blessing (or cursing) the newborns or newlyweds, thus ensuring them a position of great respect. Years later, the British government implemented laws that made hijra practices of earning a living as illegal, which marginalized and stigmatized them. Even after independence, they continued to face discrimination due to the societal stigma against transgender individuals imposed by the binaries. This coping mechanism of 'dominance' is still carried on to make subversive, the transgender community, in spite of their recognition as the 'third gender'. The proposal attempts to analyze how the inimical practice of segregation by the 'dominant' affected and still affects the transgender community in India even after the establishment of SDG 5. The central claim proposes the dominance and inclusion of the 'dominant' on transgender people still present in India through Amal Palekar's *Daayraa* (1996) and Kaushik Ganguly's *Nagakirthan* (2019) as a reference, to point out their situation.

**Keywords:** Hijra, transgenders, dominant, SDG, India, segregation, binaries

### INTRODUCTION

Television and film can be extremely powerful and impactful tools for every single individual. One's perspective of the world can be shaped by them. Focusing on the significance of films in exploring sexuality and gender fluidity, they have the power to destroy preconceptions, target marginalized populations, and expose the public visually and





**Amrita Das**

orally. It allows us to explore the subtleties of queer identities and relationships, providing a greater knowledge of the gender and sexuality spectrum. Films that include queer protagonists depict their pleasures, hardships, and victories, allowing the audience to connect on a highly emotional level. This link, in turn, fosters acceptance and knowledge, dispelling myths and encouraging inclusion. However, the influence of films on queer portrayals is fraught with difficulties. Misrepresentation, tokenism, and stereotypes, if not addressed delicately, can prolong harm and promote prejudices. In recent years, transgender people have been characterized in several ways. The term transgender is defined by Levitt and Ippolito in 2014 as "an umbrella term that refers to individuals whose gender presentation is different from the sex assigned to them at birth, which defies traditional notions of what is meant to be male or female." The hijra community in India has not always been comfortable organizing under the banner of 'transgender,' as the distinctiveness of hijras and the cultural space they occupy necessitate a different articulation (Ruchi et al. 2023). This needs to be mentioned as the paper deals with transgender people in India.

This article investigates how long-held prejudices and misconceptions against transgender people are still visible in Indian society even after the implementation of SDG 5, focusing on films like *Daayraa* (1996) and *Naagakitan* (2019) as references. It later focuses on the need to include all genders other than the binaries under SDG 5 (2015) to have equality for all, as Fannie Lou Hamer quotes, "Nobody's free Until Everybody's free." 2015 marked the adoption of the Sustainable Development Goals as a global call to eradicate inequality and build an inclusive society for all (Thomas, 2021). A road map for sustainable development has been established by the 17 SDGs, which were voted on and approved by all UN member nations (UN 2016). The SDGs' "leave-me-behind" motto, which promotes gender equality across all 17 goals, is one of their defining characteristics. Even though it was a win for the women's rights group, there is still a need for other minority groups to be analyzed and included. Unlike other films, the setting of *Daayraa* (1996) and *Naagakitan* (2019) is rather simple and domestic. It focuses on the intense portrayal of characters, which paved the way for understanding how they are treated within the binaries. Though these transgender portrayals are in a confused state, the directors debunk the idea of heteronormativity during the twentieth and twenty-first centuries. Amol Palekar's *Daayraa* (1996) covers the tumultuous events surrounding a woman who was kidnapped on the eve of her wedding and saved by a trans woman whose name is anonymous.

This depicts them not just as mere individuals but as a community that has continuously suffered through the same path. The story begins on the northeast coast of India, where an unnamed woman (played by Sonali Kulkarni) is forced into prostitution by a madam and her henchmen. Even though she managed to escape, she was gang-raped by some men while she was alone. Traumatized by the plight, she is cared for by a transwoman (played by Nirmal Pandey), with whom she falls in love. Pandey dresses her in men's clothing so they can pass as a 'straight' couple and journey back to her hometown in relative safety. The film portrays the helplessness of women in India during the 1900s. Provocative issues like rape and cross-dressing are woven together into a story using folk songs to narrate. *Daayraa* was never released in theaters due to its sensitive themes and concentration on sexuality and crimes against women, depicting the actual state of India during 1990. The film does raise issues like sexual identity, problems raised due to arranged marriages, and a woman's status in a society that does not necessarily promote equality. Pandey, a traveling performer, intentionally decides to embrace her identity and publicly live as a trans woman. Through these characters, the director portrays real-life depictions of how different genders were treated during the twentieth century. Both Pandey and Kulkarni embark on a metaphorical and literal adventure, experiencing life within the confines of a capitalist society. Nirmal Pandey holds the unique honor of winning Best Actress at the 1997 Valenciennes Film Festival in France for his portrayal in Amol Palekar's *Daayraa* (1996). The film also examines the rights of those who are not part of mainstream culture, including transgenders, gays, and lesbians. It delves deeper into their feelings and how they experience persecution from society through no fault of their own. The film's thematic daring is an exploration of the conflict between gender identity and social context in a firmly conventional country. Kaushik Ganguly's *Nagakirthan* (2019) travels through Puti's (a transwoman) hardships and struggles due to her gender identity. The story begins in Bengal, where Puti elopes with her lover, Madhu, a delivery boy at a Chinese restaurant. The flashback provides insights into Puti's childhood days when she was scolded by her father for dressing up as a girl. Later, she develops a relationship with her private tutor, Subhash da, who is aware of her gender identity. Puti advises eloping to America with him in the hopes of living freely and without concealment. She



**Amrita Das**

subsequently discovers that Subhash da is planning to marry her elder sister. Being unable to cope with the pain, she flees to the eunuch's ghetto in Kolkata, where she becomes a follower of their guru Arati. As she was living with the eunuch, she met Madhu who rents their upstairs apartment, along with an old man. Slowly, both start to develop feelings for each other and spend more time together. Understanding the greatest dream of Puti to be a trans woman through Nirvana, Madhu supported and helped her in every way possible, for which he even decided to sell all his properties. Later they decided to visit Madhu's village in Kirtaniya, Nabadwip. Ganguly's depth full portrayal of each scene carries a meaning, including the depiction of Madhu's family members as kirtans who worship Chaitanya Mahaprabhu. Madhu and his family, along with Puti, decide to attend a kirtan performed by him, during which Puti, immersed in her memories, breaks down and loses her wig during the process. She runs away, and Madhu follows but loses her. Except for his sister-in-law, everyone blames him for having a relationship with Puti. Meanwhile, Puti, devoid of all her money and belongings, starts to beg for money to have food from a nearby food stall. The local eunuchs of Nabadwip, enraged by this and aware of the reputation of phonies acting up as eunuchs to rob people, apprehend Puti, and crowd her in the streets. Madhu, in search of Puti, finds a man who captured Puti's pathetic and helpless situation. When he reaches the police station, he finds Puti hanging herself inside the lockup.

In the end, Madhu da joined the same ghetto in Kolkata. The character Madhu is significantly a queer character who finds himself in a confused state of gender, as portrayed in the climax shot. Nagakithan and Daarya portrayed the raw lives of transgender people across India. The situations faced by women and transgender people even after the implementation of SDGs can be observed through the film Daarya. Despite gaining independence, the British imprints are still visible among Indians, especially in the treatment of the queer, even though they were well-respected members during the Mughal period. During the 1700s, they worked as counselors, guards, and attendants to the imperial harem at the court. Hijras played important roles in celebrations by executing auspicious rituals and bestowing blessings. The Mughal emperors bestowed upon them advantages such as land grants and legal powers, as well as cultural significance. It is crucial to note, however, that the treatment of hijras varied across locations and times. During the 18th and 19th centuries, there was a substantial shift in the status and treatment of transgender people due to the establishment of British colonial rule. The British colonizers imposed their Victorian morality, which did not accommodate Indian society's cultural acceptance of gender variety. During this time, they experienced increased social exclusion, discrimination, and prosecution as British beliefs towards gender and sexuality diverged from pre-colonial India's historical acceptance. Overall, transgender people's experiences during the Mughal and British periods were entirely different. This colonial period continues to define the modern lives of India's transgender populations, as depicted in Nagakirthan.

**The Need for Transgender Liberation for Reduced Inequality**

The Bill, which was proposed in Parliament in 2016 and enacted in the Lower House in December 2018, provoked widespread outrage among India's transgender population. In September 2019, the Supreme Court of India commenced the Transgender Persons (Protection of Rights) Act, which was brought into practice for the protection of transgender people. The re conceptualization of SDG 5 is necessary to produce a more expansive understanding of gender equality that trans and gender-diverse people can mobilize politically, legally, and socioeconomically to disrupt cisgender-centric approaches to inclusive development. Currently, the United Nations (UN), along with other transnational organizations and corporations, appear to be stuck in a never-ending cycle of gender equality politics—clinging to a binary sexual difference. This paves the way to gender diversity politics, which produces a growing list of sexual and gender minorities that require protection (Engel, 2021). Contemplating the topic of constructing feminist futures, Camminga declares that she is not interested in feminism and wants to only make men and women equal. By making this claim, Camminga draws attention to and disproves the underlying theory that genuine gender equality that benefits everyone can result from cisnormative interpretation. Therefore, Matthyse makes an intriguing argument that a true definition of gender equality recognizes the diversity of gender identities and gender expressions to achieve liberation from gender-based oppression.





**Amrita Das****Theoretical Framework**

From the primitive period to the modern era, sociologists have addressed the phenomenon of violence as a sociological human condition that accompanied the existence of human beings as a behavior related to the animal instinctive aspect of "love of survival" and control over nature and its material goods (Asbahy & Aleemudhin, 2020). Bourdieu presents the concept of symbolic violence, which plays an important part in his study of dominance in general and is essential in understanding how inequitable gender relations are maintained (Bourdieu & Passeron, 1997). He described it as soft violence, concealed, undetectable, and unknown to both its practitioners and its victims. This violence is mirrored in emotional, valuable, moral, and cultural practices and uses symbolic tools such as language, pictures, signs, semantics, and meanings (Asbahy & Aleemudhin, 2020). According to Bourdieu, those in authority can impose language, meaning, and symbolic systems on others, which helps the dominant party maintain its position throughout. He attempts to explain how underlying power dynamics in social systems sustain hierarchies and inequalities, masking how certain groups within society get marginalized (Shepherd & Hamilton). According to Bourdieu, the minority's complicity arises when they accept uncritical concepts produced by the dominant group as the way things are and should be: Of all the forms of 'hidden persuasion' the most implacable is the one exerted, quite simply, by the order of things' (Bourdieu & Wacquant 168).

Bourdieu analyzes symbolic violence in the context of everyday practices, demonstrating how symbolic violence goes unreported due to misrecognition. Symbolic violence is not only a component of a larger continuum of violence but also the most prevalent, hidden, and trivialized kind of violence against trans women. Bourdieu's work explores "why it is that many forms of domination persist with relatively few challenges" (Chambers, 327). Furthermore, according to Bourdieu (201), the lens of symbolic violence "enables us to anticipate the conditions under which a genuine gender revolution might become possible." Bourdieu's articles concentrate on the fixed binary of masculinity and femininity, with a focus on women's liberation. However, such a gender revolution has the potential to go even further and properly recognize the multiplicity of genders. It is a matter of daily construction to determine who is the subject or object. Bourdieu also ponders how it is viewed in many ways based on the position and disposition of gender in sign, symbol, and meaning. It perpetuates the symbolic hierarchy that leads to discrimination, marginalization, and dominance.

**Analysis**

There is a real need to include transgender people within SDG 5 due to the difficulties that they pass through daily. Firstly, misgendering is a challenge that trans people face in social interaction, which occurs when someone refers to, describes, or addresses a person as a gender other than the one they identify with (Edmonds, 2023). It is one type of symbolic violence faced by trans women and trans men, in which others purposefully or inadvertently refer to them using erroneous gender pronouns or names that do not correspond to their gender identification. Misrecognition of symbolic violence means "practices that would ordinarily be deemed problematic or 'violent' eventually gain social acceptance through particular discourses, practices, and policies" (Thapar-Björkert et al. 149). This behavior undermines their self-identity and supports the perception that they are not who they are, causing emotional misery and estrangement. Misgendering in films demonstrates a lack of empathy and information about transgender issues, eventually depriving these characters of their dignity. The depiction of the struggle of being misgendered is appropriate for the story being told; however, it is often done gratuitously, or the misgendering is not addressed by the narrative. In Daaryaa, Kulkarni asks Pandey his pronouns so as not to offend him. The practice of misgendering, whether deliberate or unintentional, worsened the erasure of their gender identities and experiences. The "reveal" of a character's gender identity as a transgender person is handled as a surprise story twist, supporting the notion that transgender identities are deviant or deceptive. This sensationalistic approach can encourage transphobic sentiments and contribute to negative perceptions. In films, the deliberate "reveal" of a character's gender identification as a surprise plot twist adds intrigue and depth to the story. The approach Madhu's family had towards Puti when they found out her true gender identity portrays the transphobic attitudes of society. The scene created a strong emotional impact, causing Puti to run away from them. As they discover Puti's true identity, Madhu's family drives them from their Nabadwip home, serving as a harsh critique of humanity's hypocrisy. The livelihood of Madhu's family as



**Amrita Das**

Vaishnava Kirtanias, accepted by Chaithanya Mahaprabhu when reflected in a man of flesh and blood, her true identity disgusts them. This shows the bitter truth in our society. On the one hand, transgender people are shunned and ostracized, but on the other hand, they are thought to be spiritually or religiously superior, leading individuals to feel that the community's blessings will aid them. This can be a two-edged storytelling strategy that presents provocative concerns about their representations. In Daayraa two characters (Pandey and Kulkarni) are involved in a conversation during their first meeting:

PANDEY. I am a miracle of nature

KULKARNI. You..What are you?

PANDEY. Without, a man. Within, a woman (19:48-57)

The representation of the first contact with transgender people can be a critical moment that has the opportunity to handle complex issues of identity, understanding, and empathy. Open conversations, as mentioned above, play a significant role in dispelling misunderstandings and fostering a sense of growth for the characters involved. Many "positive" stories depicting trans women end with their death portrayals. In Daayraa (1996) and Nagakirthan (2019), the trans characters are killed or are forced to hang themselves due to the cisnormative norms around them. These films chose to present a tragic end as a result of continuous assault or discrimination. The endings can highlight the harsh reality that transgender people frequently endure, shedding light on topics such as hate crimes and lack of support. Puti was portrayed as a victim of the cisnormative society. Her death reflects a deeply embedded cultural bias that prioritizes traditional gender identities and relationships. The men who tried to rape Kulkarni attacked Pandey and shot her. The unfulfilled desire of Pandey to live as a woman shows the upper hand of cisnormative society over the trans community. The repeated depiction of transgender individuals meeting terrible ends promotes negative preconceptions and reinforces the notion that their lives are intrinsically tragic. This reinforces the idea that transgender people are outcasts, unable to achieve happiness or fulfillment within conventional standards.

**CONCLUSION**

For the attainment of both the general and human rights aspects of the sustainable development goals, deeper knowledge is required—an intersectional and critical approach, that is, a post-colonial, de-pathologizing, non-binary, global understanding of what is commonly called 'gender'. It is well known that the categories of "sex" and "gender" refer to far more diverse and complex phenomena than specific views of men and women when discussing Sustainable Development Goal 5 (Baumgartinger, 2021). As a first step, there is a need to prepare a world that is not just safe for cisgender people but also queer individuals. So there is a necessity to intensify efforts to create political understanding that permits the inclusion of transgender and gender diverse people in the broader global conversation on gender equality. Films have increased transgender exposure while retaining the mainstream cisnormative community. The historical prohibition of some gender expressions by British colonial rulers is shown in films through unfavorable portrayals of transgender people as lawbreakers or societal misfits. This portrayal recalls the punishing sentiments fostered by colonial-era regulations. Still, the lingering influence of British colonial views remains evident in films as well as within the cisnormative society that is depicted in Daayraa and Naagakirtan. Despite the progressive conclusions obtained by the Department of Social Justice and Welfare, which include the Transgender Persons (Protection of Rights) Bill of 2019, much more work needs to be done to bring gender and sexual diversity into line globally. And to hold the state responsible for the gender minorities it displaces, all the while pursuing the goal of "inclusive development" for everybody. With the implementation of Transgender Persons (Protection of Rights), it is clear that there is a need to educate the people around them more than consider transgender people under SDG 5.





Amrita Das

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## Smart System For Live Human Detecting Robot for Disaster Rescue Operation using IoT

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### ABSTRACT

Natural catastrophes and calamities such as building collapse, post-tsunami, earthquakes are some of the most disastrous situations mankind faces and, in such circumstances, rescuing survivors is the most critical job. The swarm robots in the present project are governed by a centralized system where all the bots connect to a common IoT cloud. Through this connection, they communicate and store all the accumulated data. The bots also utilize several sensors such as GPS location tracker, an ultrasonic sensor for obstacle and edge detection for maneuvering purposes, LM35 temperature sensor. The current system is also developed with a unique novel hybrid 6-wheel design which will facilitate easy maneuvering over rough terrain. In disaster rescue operations, the timely detection of live human presence is crucial for optimizing search and rescue efforts. This paper introduces a Smart System for Live Human Detecting Robot designed for disaster response scenarios. Leveraging the Internet of Things (IoT) technology, the proposed system enhances the capabilities of rescue robots by providing real-time data on the presence of live humans in disaster-stricken areas. The system integrates advanced sensors and IoT devices to detect vital signs and human movements, enabling efficient and rapid identification of survivors. This innovation aims to improve the overall effectiveness of disaster rescue operations, ensuring a swifter response and increased chances of saving lives. This paper discusses the design and development of swarm robotics, which can be employed in such disasters to search for survivors and for various research purposes.





Sivakumar et al.,

**Keywords:** Disaster Rescue, IoT (Internet of Things), Smart System, Live Human Detection, Rescue Robot, Disaster Response, Vital Signs Monitoring, Human Presence Sensing, Search and Rescue, Emergency Operations.

## INTRODUCTION

Swarm robotics, a subset of multi-robotics, involves the coordination and communication of numerous robots in a decentralized manner to achieve a common goal. Drawing inspiration from the behaviors of insects like birds, bees, and ants, these simple swarm robots operate based on local rules. In comparison to a complex singular robot, a large number of these robots exhibit robustness and efficiency in performing intricate tasks. In the context of search and rescue missions, swarm robotics proves particularly effective, as the collective can efficiently cover affected areas, assist each other in case of breakdowns, and communicate via the cloud for seamless coordination[1]. The implementation of swarm robotics for search and rescue is demonstrated in various scenarios. One application involves swarm robots following firefighters in a building, navigating lower areas with lower smoke and temperature to aid in finding humans and guiding firefighters. Another swarm robot, equipped with a robotic arm, maneuvers on small rocks and wreckage via Bluetooth control from a mobile device. Blue Swarm 2.5 focuses on cost-effectiveness[3], incorporating sensors for obstacle detection, collision avoidance, and heat signature detection from survivors. An all-terrain robot with a robotic arm is proposed for surveillance tasks, utilizing cameras, thermal imaging, ultrasonic sensors, and autonomous terrain mapping.

Several challenges and considerations arise in the development of swarm robotic systems. The issue of area coverage is addressed through the use of swarm robotics, but potential drawbacks include the lack of an edge detection system, which could lead to disasters in search missions with steep terrains. Rescue operation systems utilizing GPS tracking face challenges such as irrelevant data from PIR sensors and random traversal, potentially leading to repeated search areas and wasted time. Various robots designed for rescue operations[2] incorporate features like thermometers, lifting arms, RF communication, and even an Android app for control. In summary, the integration of swarm robotics with nanoscience, nanotechnology, nanorobots, and computer science showcases a diverse range of applications in the medical and rescue domains. While these innovations present solutions to complex challenges, careful consideration of ethical, technical, and practical aspects remains crucial for their successful implementation in real-world scenarios[4]. Various robots have been developed for autonomous search and rescue missions, employing advanced technologies for improved efficiency. One approach involves the use of thermal array sensors to detect body heat and autonomously navigate into search areas to locate human survivors.

Despite its effectiveness in locating survivors, the reliance on signal strength for location tracking introduces potential inaccuracies. Another robot is designed specifically for autonomous exploration and mapping tasks, focusing on areas with a high probability of locating victims while minimizing conflicts during exploration. This emphasizes resource allocation for optimized efficiency in search and rescue operations[4]. Innovative designs for robots with specialized capabilities have been introduced. A robot with a wheel-legged system is highlighted for its ability to carry heavy weights and implement real-time transformations in the field, facilitating maneuvering in rough terrains[5]. Another wheel-legged design showcases three different states: rotation center lift, leg motion, and a normal wheel state, demonstrating feasibility for various applications. An alternative approach utilizes a 4\*4 high-power wheel system and a robotic arm to manipulate obstacles instead of avoiding them, providing a unique solution for navigation in challenging environments[1]. In the realm of industry applications, a method is described wherein fixed temperature sensors in industrial environments can be moved using a robot to detect temperatures in different locations. Additionally, the utilization of DTMF technology is discussed for controlling and communicating sensor data and devices, with data processing handled by an Arduino UNO. The development of an IoT robot aims to enhance safety in coal mines by sensing toxic gas levels and temperature[2], alerting workers to potentially hazardous conditions. Another IoT robot is designed to assist the elderly in performing basic tasks, incorporating features such as face detection, live streaming home surveillance, and Bluetooth remote control. The potential of





**Sivakumar et al.,**

swarm robotics in search and rescue for first responders is explored, discussing the evolution of the Blue Swarm and introducing various robot models such as Scout, Scout Walker II Beam, and Crawler Robot. A survey on existing swarm robot methodologies is conducted, experimenting with five advanced algorithms for exploration. The results indicate that the Robotic Darwinian Particle Swarm Optimization (RDPSO) algorithm outperforms several other algorithms in terms of efficiency and effectiveness. These developments underscore the diverse applications and continuous advancements in robotic technologies for search, rescue, and various specialized tasks.

**Objectives**

The smart system for a live human detecting robot in disaster rescue operations using the Internet of Things (IoT) has several key objectives aimed at enhancing the efficiency and effectiveness of rescue operations during disasters[2].

**Live Human Detection**

The primary objective is to develop a robot equipped with advanced sensors and technologies to detect and locate live humans in disaster-stricken areas. This involves the integration of sensors capable of detecting vital signs, such as heat signatures or movements, to ensure the timely identification of survivors[3].

**IoT Integration**

Utilize IoT technologies to enable seamless communication between the robot and a centralized control system. This involves incorporating sensors, actuators, and communication modules that can relay real-time data to the control center, allowing for swift decision-making and coordination of rescue efforts[4].

**Autonomous Operation**

Implement autonomous navigation and operation capabilities to enable the robot to navigate through challenging terrains or environments without direct human control. This involves developing algorithms and systems that allow the robot to make decisions based on its surroundings and the data collected through sensors[5].

**Remote Monitoring and Control**

Facilitate remote monitoring and control of the robot by rescue teams. This objective aims to provide real-time video streaming, telemetry data, and control functionalities through the use of IoT technologies. Remote monitoring ensures that rescue teams have a comprehensive view of the disaster site without physically being present[4].

**Survivor Condition Monitoring**

Integrate sensors capable of monitoring the health and condition of survivors once detected. This includes sensors for measuring vital signs, assessing the environmental conditions, and providing relevant data to rescue teams for informed decision-making[3].

**Obstacle Avoidance and Navigation**

Develop robust algorithms and systems for obstacle avoidance and navigation to ensure the robot can navigate through debris, rubble, or challenging terrain without getting stuck. This enhances the robot's capability to reach survivors in difficult-to-access locations[5].

**Scalability and Adaptability**

Design the SMART SYSTEM to be scalable and adaptable to different disaster scenarios. The robot should be capable of handling various types of disasters, including earthquakes, floods, or fires, and be easily deployable in different environments and conditions[2].

**Energy Efficiency**

Focus on optimizing the energy consumption of the robot to ensure prolonged operation during rescue missions. This involves incorporating energy-efficient components, power management systems, and possibly renewable energy sources to enhance the robot's endurance[3].

**Human-Robot Interaction**

Develop interfaces and communication systems that facilitate effective interaction between the robot and rescue teams. This includes features that allow operators to provide specific instructions, receive status updates, and control the robot remotely[4]. By achieving these objectives, the smart system aims to contribute to more efficient and technologically advanced disaster rescue operations, ultimately increasing the chances of successfully locating and rescuing live humans in critical situations[5].







## LITERATURE SURVEY

The literature survey on the "Smart System For Live Human Detecting Robot For Disaster Rescue Operation Using IoT" encompasses a broad exploration of research related to disaster rescue, IoT applications, smart systems, live human detection, and the integration of these technologies in rescue robots[3]. In the context of disaster management and detection, the project type -1 aims to leverage IoT-based wireless sensor techniques to detect and manage specific types of disasters. The paper highlights the increasing importance of total automation in various aspects of human life, citing IoT as a boon with applications in smart cities, agriculture, industrial control, security, and medical applications. The integration of IoT is seen as a key enabler for complete automation[1], reducing human efforts through machine-to-machine interactions. The type-2 focuses on wireless sensor networks for disaster management, emphasizing their self-organization and self-configuration capabilities. The author proposes using this network to minimize loss of life during disasters by collecting data to make informed decisions for rescue teams. Techniques for Landslide Detection, Forest Fire Detection, Tsunami Detection, and Microcontroller-based Earthquake Detection are discussed. The two-layer approach involves data collection from sensors, transmission to a gateway using ZigBee components, and sending alerts through text messages or SMS for timely evacuation[1].

The type-3 introduces a robot for detecting human presence in disaster scenarios, controlled using an earthquake phone. The robot utilizes PIR sensors and DTMF tones for operation, making it remotely controllable from anywhere in the world. The author suggests applications beyond rescue operations, such as military use for detecting unwanted presence. The robot is equipped with sensors like ultrasonic, PIR, temperature, and oxygen sensors to detect obstacles, motion, and potential fires during rescue operations[2]. In the type-4 an inexpensive autonomous robot is proposed for distress situations. The model integrates RF technology and an ARM7 controller with sensors like PIR, IR, and temperature sensors. The IR camera is recommended to enhance the project's effectiveness. The fifth paper presents the hardware and software implementation of an earthquake-controlled robot, showcasing results from various sensors in graphical and tabular formats. Both papers highlight the potential of affordable robots in minimizing loss of life during disasters[3]. Firstly, the survey delves into the domain of disaster response and rescue operations. Various studies highlight the critical challenges faced by emergency responders during disasters, emphasizing the need for advanced technologies to enhance the efficiency and effectiveness of rescue missions. The survey underscores the urgency of employing innovative solutions to address the complexities of disaster scenarios, where time-sensitive actions are paramount[4].

The role of IoT in disaster rescue operations is a central theme in the literature survey. Researchers emphasize the integration of IoT technologies to enable real-time communication and data exchange between rescue robots and control centers. This integration facilitates remote monitoring, decision-making, and coordination, thereby optimizing the overall effectiveness of rescue efforts. Studies showcase how IoT can be leveraged to create a connected and responsive ecosystem, allowing for seamless communication and control in dynamic disaster environments[5]. The survey delves into the concept of a "Smart System" for disaster rescue robots, highlighting the importance of developing intelligent and adaptive systems. Smart systems are designed to autonomously navigate through disaster-stricken areas, employing advanced algorithms and sensors to detect live humans. These systems prioritize adaptability, scalability, and energy efficiency to ensure robust performance in diverse disaster scenarios, aligning with the evolving needs of emergency response teams. Live human detection emerges as a critical objective in the literature survey, emphasizing the development of rescue robots capable of sensing vital signs and human presence in disaster-affected areas. Researchers explore various sensor technologies, including thermal arrays and movement detectors, to enhance the robot's ability to locate survivors accurately. The incorporation of autonomous navigation further contributes to the robot's efficacy in navigating complex terrains and debris during search and rescue missions. The survey recognizes the significance of vital signs monitoring in disaster scenarios. Researchers propose integrating sensors that monitor survivors' health conditions[3], providing crucial data to rescue teams for informed decision-making. This aspect ensures that the rescue robot not only detects human presence but also assesses the well-being of survivors, contributing to a comprehensive and life-saving approach in disaster





Sivakumar et al.,

response[1]. In summary, the literature survey reveals a multifaceted exploration of disaster rescue robotics, IoT applications, smart systems, live human detection, and vital signs monitoring. The integration of these technologies is poised to revolutionize disaster response[3], offering more efficient, connected, and adaptable solutions to mitigate the impact of disasters on human lives[2].

### Existing System

The existing systems for live human detecting robots in disaster rescue operations using IoT have witnessed significant advancements, leveraging a combination of technologies to enhance efficiency and effectiveness. These systems typically incorporate IoT components for real-time communication, smart sensors for live human detection, and autonomous navigation features for effective disaster response. The integration of these elements creates a connected and responsive ecosystem, allowing rescue robots to operate in dynamic and challenging disaster environments[4]. In the existing systems, IoT technologies play a crucial role in enabling seamless communication between the rescue robot and centralized control centers. Remote monitoring, decision-making, and coordination are facilitated through the exchange of real-time data, providing rescue teams with valuable insights into the disaster scenario. The utilization of smart systems allows for autonomous navigation, enhancing the robot's ability to navigate through complex terrains and locate live humans efficiently[5]. Additionally, these systems often incorporate vital signs monitoring, ensuring a more comprehensive approach to assessing the well-being of survivors[3].

### Drawbacks of Existing System

Despite the advancements, existing systems for live human detecting robots in disaster rescue operations using IoT face certain drawbacks and challenges[2] that researchers and developers are actively addressing:

#### Limited Scalability

Some existing systems may face challenges related to scalability, especially in large-scale disasters. The ability to deploy a sufficient number of robots to cover extensive disaster areas without compromising efficiency remains a concern[1].

#### Energy Consumption

The energy efficiency of these systems is a critical consideration. Operating in disaster-stricken environments may require prolonged operation, and ensuring an adequate and sustainable power source for the rescue robots remains a challenge.

#### Sensor Limitations

While the integration of sensors is crucial for live human detection, some existing systems may face limitations in the types of sensors employed. Issues such as sensor range, accuracy, and adaptability to different disaster scenarios may impact the overall effectiveness of the system.

#### Communication Reliability

The reliability of communication between the rescue robot and control centers is essential for real-time decision-making. Challenges such as signal interference, connectivity issues, or delays in data transmission can hinder the effectiveness of the system.

#### Adaptability to Diverse Environments

Disaster scenarios vary widely, and existing systems may encounter challenges in adapting to diverse environments such as earthquake-ridden areas, flooded regions, or fire-stricken locations. Ensuring that the system remains effective across different disaster types is an ongoing consideration[3].

### Cost Constraints

The cost of developing and deploying sophisticated robotic systems with IoT capabilities can be a limiting factor. Balancing the need for advanced technology with cost-effectiveness is crucial for widespread adoption and implementation. As the field of disaster rescue robotics using IoT continues to evolve, addressing these drawbacks is essential to ensure the development of robust, scalable, and adaptable systems that can effectively respond to a variety of disaster scenarios. Ongoing research and technological innovations aim to overcome these challenges and further enhance the capabilities of live human detecting robots in disaster rescue operations.





Sivakumar et al.,

## PROBLEM DISCUSSION

The concept of employing a smart system for live human detection in disaster rescue operations through IoT technology is full of potential, offering innovation and promise. However, its implementation is accompanied by numerous challenges. Two critical factors affecting the system's performance are reliability and accuracy. False positives, where non-human objects are mistakenly identified as humans, can lead to unnecessary alarms, while false negatives pose a serious risk by failing to detect actual humans in need during rescue operations[1]. Environmental factors further compound the challenges. Disasters create harsh conditions, introducing debris, smoke, water, and other obstacles that can compromise the accuracy of sensors and data transmission. Limited visibility due to poor lighting conditions or environmental factors like dust and fog may hinder the system's effectiveness in identifying live humans[4]. Power consumption emerges as a significant concern, especially in disaster-stricken areas where obtaining a stable power supply is challenging. Efficient power management is crucial for the continuous and reliable operation of IoT devices. Communication issues also loom large, with the system heavily relying on real-time communication between devices. In disaster-stricken areas, damaged or unreliable communication infrastructure can impact overall system performance, introducing latency that may affect the timeliness of rescue operations[5].

The scalability of the system presents logistical challenges, requiring careful planning, coordination, and logistics for the deployment and maintenance of numerous devices in disaster-stricken areas. The associated costs, both in terms of development and deployment, are substantial, potentially limiting the widespread adoption of this technology in disaster management[4]. Privacy and ethical concerns add another layer of complexity. Continuous monitoring for human detection raises privacy issues, necessitating a delicate balance between the need for rescue operations and respecting individuals' privacy rights. Ensuring data security is crucial to prevent unauthorized access or misuse of the information collected by IoT devices. Integration with existing systems, such as disaster management and rescue operations frameworks, poses complexity and may require standardization. Maintenance and durability are additional challenges, as devices deployed in disaster-stricken areas must withstand harsh conditions, and regular maintenance may be difficult, impacting the overall reliability of the system. Finally, regulatory challenges related to compliance with local and international regulations on data privacy, surveillance, and disaster management add a layer of complexity to the implementation process. Addressing these multifaceted challenges demands a multidisciplinary approach, bringing together expertise in IoT, robotics, disaster management, and regulatory frameworks. Only through such a comprehensive approach can the successful implementation[1] of a smart system for live human detection in disaster rescue operations be ensured.

### Proposed System

The proposed mobile rescue robot aims to operate in disaster and earthquake-stricken areas, assisting in the identification of live and injured individuals while facilitating rescue operations. This innovative system seeks to detect and respond to natural disasters promptly, potentially saving lives and minimizing losses, even in the absence of a large number of rescue operators. Comprising a mobile rescue robot and earthquake control, the system utilizes a sensor unit, microcontroller, motor driver unit, and transmission unit to enhance its capabilities. The Earthquake rescue robot incorporates sensors such as ultrasonic, oxygen, temperature, and PIR (Passive Infra-Red) sensors to monitor environmental conditions in disaster areas. These sensors feed real-time data to the ATmega328 microcontroller, a low-powered, low-cost microcontroller commonly used in projects and autonomous systems. The microcontroller plays a central role in gathering sensor data in real-time, transmitting information to the control room's CPU, receiving commands from a mobile app, and facilitating the robot's movement during rescue operations. The robot's driver unit manages the robot's movement in the x-axis and y-axis using a conveyor belt-type mechanism and four DC motors. The robot's ability to navigate through debris and rugged terrain is facilitated by positive and negative pulse edges, enabling forward, backward, left, and right movements. The transmission unit, employing a Bluetooth module, transmits data from the microcontroller to the receiver. At the receiver end[5], displayed on a PC or app, real-time data and weather parameters aid in locating humans, facilitating prompt rescue operations. The applications of this system extend to forest fire detection, human body detection under debris,



**Sivakumar et al.,**

sensing unwanted presence for security purposes, and weather monitoring, showcasing its versatility and potential impact on various scenarios.

### Advantages of Proposed System

The proposed project showcases versatile applications, with one significant use being forest fire detection. Equipped with sensors, including a temperature detector, the robot can detect rising temperatures indicative of a potential fire. Upon reaching a predetermined threshold[3], the temperature sensor triggers an alarm. Additionally, the system incorporates a smoke detector to identify the presence of smoke and combustible oxygen, while the humidity sensor further aids in recognizing hot weather or fire conditions. The robot, designed for mobility in forests, remains vigilant and can alert authorities to potential fire outbreaks. Another critical application involves human body detection under debris, applicable in incidents such as earthquakes, tsunamis, or airplane crashes. Utilizing infrared radiation emitted by the human body, the robot employs a PIR sensor to ensure the detection of human presence even in challenging scenarios[5]. To navigate obstacles, an Ultrasonic sensor is used, allowing the robot to sense entities using ultrasonic waves. This capability has the potential to save numerous lives by aiding in the rescue of individuals trapped under debris during emergencies. The project extends its utility to security operations by employing the PIR sensor for sensing unwanted human presence. This feature can be utilized for various security purposes, such as detecting intruders in a room or near the main door. The system can alert homeowners in real-time, enabling timely responses and the possibility of contacting law enforcement to prevent theft or robbery. Moreover, the integration of a camera with the PIR sensor enables parents to monitor their children, enhancing overall security within a household[1]. Beyond these applications, the project proves valuable for weather monitoring both indoors and outdoors. With precise sensors, it facilitates the maintenance of proper indoor air quality index. This adaptability makes the system not only a tool for emergency response but also a useful asset for everyday environmental monitoring, showcasing its broad range of applications and potential impact[4].

## MATERIALS AND METHOD

The project involves the use of various components, each serving a specific purpose in creating a disaster management system. One critical component is the battery, converting stored chemical energy into electrical energy. Batteries are categorized into primary (disposable) and secondary (rechargeable) [5]. The capacity of a battery depends on factors such as discharge conditions and the rate at which it is discharged. The project utilizes LM35 as a temperature sensor, measuring temperature and humidity, and MQ2 as an oxygen sensor, detecting various combustible gases. The PIR sensor is employed for motion detection. The LM35 temperature sensor operates within a range of -40 to 80 degrees Celsius, providing accurate readings with a quick response time. The MQ2 oxygen sensor is sensitive to combustible gases, operating on a 5V power supply and offering both digital and analog outputs. The PIR sensor, functioning as a motion sensor, detects infrared rays emitted by the human body. Each sensor plays a crucial role in environmental monitoring during disasters. The ESP32, an open-source electronic platform, serves as the microcontroller, operating at 5V with 14 digital I/O pins. The project also incorporates a Bluetooth module (HC-05) for wireless communication. The L298N motor driver handles the movement of the robot. The project's future work involves the implementation of swarm robots for search and rescue operations, utilizing RF communication for interconnection and thermal cameras for survivor detection. The integration of IoT technology, sensors, and communication modules creates a comprehensive disaster management system with real-time monitoring and alert capabilities.

### Implementation

Implementation is the stage, which is crucial in the life cycle of the new system designed[3]. The implementation phase is starting at process installing software and hardware and requirements. Installation hardware is setting up the PC desktop hardware requirements specification.



**Sivakumar et al.,****Hardware Implementation****Body**

The body of the robot is CAD designed using the Autodesk Fusion 360 software. And 3D printed using a biodegradable poly lactic acid (PLA) 3D printing filament. The 3D printed parts are then assembled together[1].

**Node Mcu**

It is used as the processor of the swarm robots as it is smaller in size inexpensive and has the capability of connecting to the internet via the inbuilt ESP8266 Wi-Fi module. Shown in image 3. It has several GPIO pins and has storage of 4MB runs on XTOS and it is energy efficient, which is essential in swarm technology. All the sensors and IO devices such as Ultrasonic sensor, GPS module, L239D, and temperature sensor is connected to the Node Mcu[5] and the IO is processed. Two Node Mcu is used due to lower number of IO pins. The CPU has 80Mhz frequency.

**Power supply**

The entire project is drawn from three different sources one 13000mah power bank for Node Mcu, sensors. And a separate 9V power supply for the L239D driver and 6300RPM geared motors robot movement as it requires 9 volts. A 6v solar panel is installed on top of the robot which recharges the rechargeable batteries during the search operation[5], power from the solar panel ensures that the robots will sustain in the field of operation for a longer period of time.

**GY-GPS6MV2 GPS module**

It is used for location tracking. The module has a Ceramic antenna which can connect to several satellites to determine the exact location and also has EEPROM to save configuration data when there is no power supply. This module is used in this project to track the location of the robot in the search area, and also to identify the survivor's location. These location data are sent to the cloud for analysis[4].

**Temperature sensor**

LM35 temperature sensor is attached to the Node Mcu in order to accumulate live temperature data. This sensor can detect temperatures from -55 degree to 150 degrees. The raw input data is collected from the IO pin. The formula below is used to convert raw data to accurate temperature value[3].  $Temperature = (5.0 * input\ data * 100.0) / 1024$  This data can be used by the rescue team during a search operation to check if the temperature is too high inside buildings if any fire explosion has occurred. Shown in figure 3.

**Ultrasonic sensor**

HC-SR04 used in this project is capable of emitting 40000Hz ultrasound. As shown in the figure 4 the trigger pin in the sensor will emit ultrasound and the waves will reflect back when it strikes an object and the reflected waves is received back by the echo pin and the time duration of sent wave and received wave is calculated and the time is converted to distance, Formula used to calculate distance is  $distance = (duration/2) / 28.5$  where distance and duration are initialized to 0 initially[1]. the threshold is set to 30cm distance and area of propagation is above 5-6 cm above ground level. Obstacles that are 5-6cm in height from ground level is moved over by the hybrid wheel system. This data is used to detect objects in front of the robot while moving. The robot makes use of the ultrasonic sensor data to avoid obstacles and continue searching operation without crashing into any objects[1]. The robot moves around the obstacle instead of taking a random path as designed in[5], this optimizes the search process and reduces the time to search and excludes redundant search[3]. A second ultrasonic sensor with same configuration is used to detect edges in the search area. The same principle is used as the obstacle avoidance, but the sensor will be facing the floor and as soon as the distance measured is greater than 7cm the robot detects it as an edge. And the robot will change its path avoiding the edge[4].

**L239D motor driver**

L239D H-Bridge motor driver is used to drive the geared motors. The H-bridge will allow the DC current to flow in both directions. Which will allow the motors to rotate in both the directions [2], this mechanism is used to make the







Sivakumar et al.,

robot move left, right and straight back. The left row of three wheels are connected as one connection to the L239D and similar to the right row of wheels, the robot moves forward when the H-Bridge powers both left and right as high, it moves back when it's powered low, to move left only the right set of wheels are powered high, for right all left wheels are powered high, As shown in the table 1.

### Hybrid wheel system

This system unique novel 6 wheel is design shown in figure 5 is designed in such a way that the front section wheels are capable of swinging from 0 to 180 degrees with the help of a rotator shaft, helping in climbing small rocks and obstacles while the back wheels provide support. 6 300RPM geared motors are used for movement. Front two wheels are connected with each other using chain links which makes the robot hybrid of both tanker wheel system and normal rovers, the hybrid wheels can maneuver over obstacles which are at the height of 5-6 cm, and the obstacles that are higher than 5-6 cm is detected by the obstacle sensor and ensures the robot takes a different path. The rotator shaft is also equipped with two suspension springs which will help in moving and reduce damages on the electronics, also will ensure the robot is stable while climbing over small objects[1].

### Software Implementation

Arduino IDE is used to program the swarm robot using embedded cpp language. Google firebase cloud service is used to store and view all the data sent by the Node Mcu and sensors. To connect to the Google firebase host connection link and secure authentication id is included in the code which is provided by the firebase cloud. And to communicate with the cloud the Node Mcu ESP8266 needs to be connected to a WIFI network[3]. The robots use the firebase cloud as a platform to communicate with each other and to receive the area to be searched and dived the area among them self. In the receiving end, both rescue team and the operation team can view the results provided by the swarm robots[5].

### Blynk

An android app called Blynk is used to view the live GPS data provided by the swarm robot, Location can also be viewed in the google cloud live database. Shown in figure 6. Using the data sent by GY-GPS6MV2 GPS module[1], the blynk app will also show the direction in which the robot is moving and the number of satellites it is connected to provide the GPS data and also it provides the live location of the robot in a map. Depicted in figure 5.

### Camera

To view the live scenario and to locate the survivors of the disaster-prone area, an old android mobile with an IP webcam mobile app is used for the viewing purpose. The live feed can be viewed by a computer, mobile or tabs by entering the IP address provided by the app[1]. Both the rescue team and the operations team can view this live feed from the camera. The operations team can also toggle the led flash remotely by the IP camera web interface. Shown In figure 6. The process of detecting survivors is to be done by the operations team by looking into the live feed of the camera[3].

### Algorithm

- Step 1: Input area perimeter to the swarm robot
- Step 2: Robot divides the area and start searching
- Step 3: If obstacle detected change direction
- Step 4: If edge detected change direction
- Step 5: Find temperature of area and transmit it to the firebase cloud database.
- Step 6: Find live location of robot and transmit location to the firebase cloud database.
- Step 7: If robot damaged assign nearest robot the task of damaged robot.
- Step 8: If human survivor found in camera retrieve live tracking location.







## RESULTS AND DISCUSSION

The proposed method highlights the swarm robot's effectiveness in navigating through rough terrain, utilizing a hybrid wheel system that facilitates movement over small obstacles like stones, sand, and grass. The ultrasonic sensor, with a 30cm detection threshold, plays a crucial role in preventing collisions by providing data for calculating the optimum path. This feature ensures that the robot can efficiently cover the entire area in search of survivors[3]. However, a drawback arises with the second ultrasonic sensor, which detects edges within a 7cm threshold. The high-powered robot moving at a faster speed poses a challenge, as the sensor's detection speed is not sufficient to promptly identify edges, necessitating a reduction in the robot's power to ensure accurate edge detection[1]. The temperature sensor proves to be a valuable component, providing accurate data for the search operation. On the other hand, the camera module, with a video capture rate of 30fps and VGA resolution, faces challenges due to the constant movement of the robot[1], causing disturbance and an unacceptable frame rate. The recommendation is to employ higher-quality cameras with better resolution and fps rates to enhance the live feed from the disaster area. These improvements would contribute to the overall efficiency and performance of the swarm robot in disaster response scenarios[2].

## CONCLUSION

The successful implementation of the swarm robot was marked by its effective functionality in response to the assigned area and perimeter. Tasked with a search operation, the robots demonstrated their capability to navigate the designated space while avoiding obstacles. Simultaneously, the rescue team efficiently utilized live feeds from the robot-mounted cameras to detect victims within the operational area. This approach to search and rescue operations proves invaluable in terms of time-saving, particularly during the critical phase of a search operation. The efficiency of the operation is expected to increase with a higher number of swarm robots, showcasing the scalability and potential for rapid execution. The hybrid wheel system employed by the robots played a pivotal role in their maneuverability, enabling them to navigate diverse terrain and overcome various obstacles seamlessly. This adaptability is crucial in disaster-stricken areas where the landscape may be littered with small objects and challenging topography. Looking ahead, the potential for further improvement [4] includes interconnecting the robots via RF communication in scenarios where Wi-Fi connectivity is unavailable in the disaster area. This enhancement would enable seamless data exchange among robots, facilitating communication between the swarm and enabling the closest robot to relay critical information to the rescue or operations team[1].

### Future Scope

IoT, as an emerging technology, holds the promise of revolutionizing daily life by minimizing human effort and intervention. The integration of IoT into various systems, as demonstrated in our project, brings forth an automated solution capable of detecting fires, rescuing people trapped under debris, sensing human presence, and even monitoring weather conditions. By establishing connections between devices, IoT facilitates seamless communication and coordination, significantly reducing the need for direct human involvement. This advancement is particularly crucial in scenarios where time is of the essence, such as disaster management, where swift and timely actions can save numerous lives. The project's use of IoT underscores its potential to enhance efficiency and effectiveness in diverse applications[1]. The project's applicability extends beyond disaster management, finding relevance in security issues where the detection of unwanted human presence is essential. Whether in restricted military areas, medical rooms, unauthorized entry into homes, or secure locations like banks and company premises, the IoT-based system offers a robust solution for monitoring and alerting. The choice of ESP32 as the project's baseline further enhances its practicality by simplifying the interfacing of components, contributing to the overall effectiveness of the system. As IoT continues to evolve, its integration into various domains promises to bring about a future characterized by increased automation and improved response capabilities in critical situations. For future iterations, the integration of thermal cameras stands out as a promising enhancement. Rather than relying on manual detection,





**Sivakumar et al.,**

thermal cameras could be utilized to identify survivors more efficiently. This advancement would not only expedite the rescue process but also enhance the accuracy of locating individuals in need. Overall, the successful implementation of the swarm robot, coupled with these potential improvements, underscores its significance in advancing search and rescue capabilities in disaster scenarios.

**ACKNOWLEDGMENT**

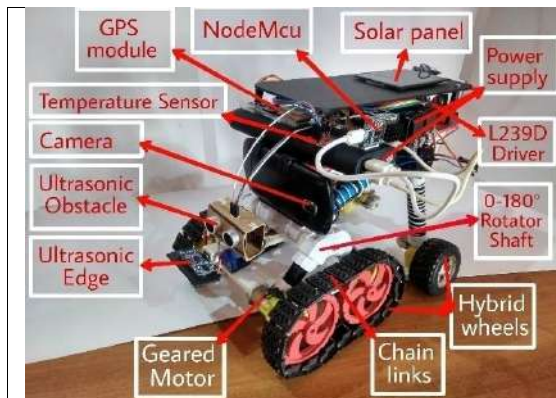
Author are also grateful to Department of Computer Science and Engineering, Vinayaka Mission’s Research Foundation (DEEMED TO BE UNIVERSITY) for offering sufficient library and internet facility.

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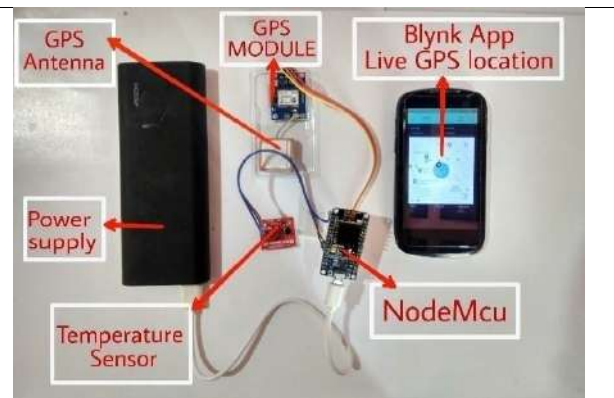
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**TABLE 1. Digital control signals for L239D driver**

Commands	Inputs(Right wheels)	Inputs(Left wheels)
Front	1	1
Back	0	0
Left	1	0
Right	0	1



**Fig 1: Hardware Implementation**



**Fig 2: GPS Module And Temperature Sensor**





Sivakumar et al.,

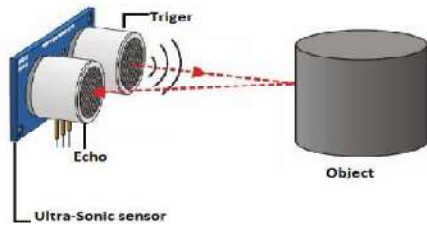


Fig 3: Obstacle Detection & Edge Detection

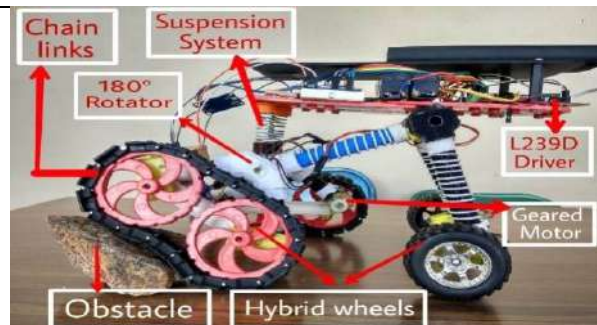


Fig 4: Hybrid wheel system

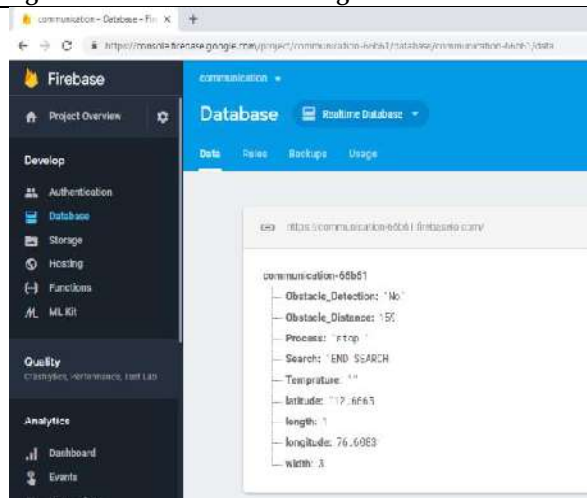


Fig 5: Google Firebase

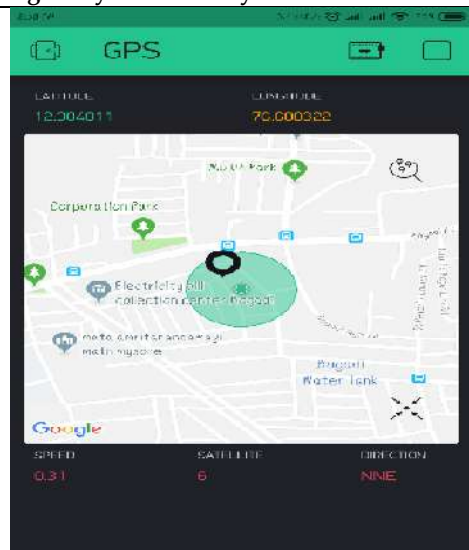


Fig 6: GPS live tracking using Blynk App

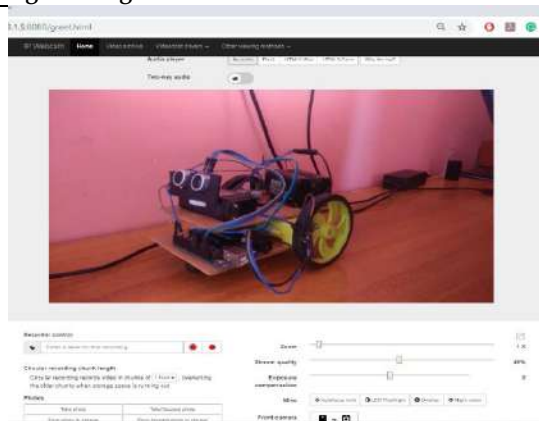


Fig 7.View from IP camera web interface

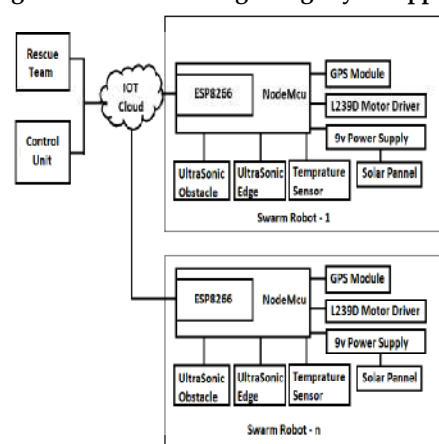
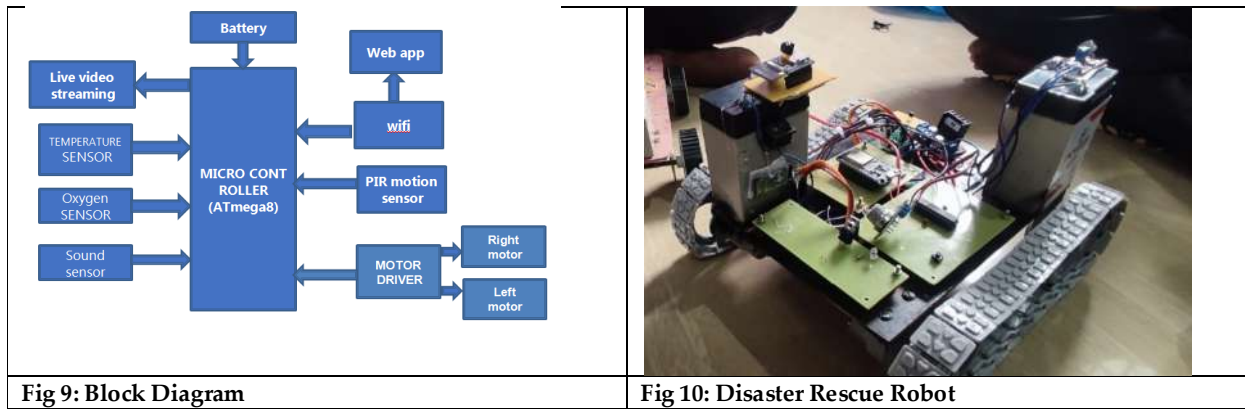


Fig 8. View from IP camera web interface





Sivakumar et al.,





## Silent Dissent: Counter-Narratives in Indian Police Memoirs

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### ABSTRACT

This research paper delves into the often-understudied aspects of counter-narratives within memoirs authored by Indian police officers. The narratives of these officers have traditionally been associated with duty, a sense of loyalty, and upholding the status quo, yet beneath the surface, a current of silent dissent flows. Drawing from a diverse selection of memoirs spanning various regions and periods, this paper explores the instances, themes, and implications of this just a position of silence and dissension in their narrative, revealing a nuanced layer of critique and reflection. These counter-narratives often challenge the prevailing norms and practices, highlighting issues such as corruption, institutional flaws, and ethical dilemmas in policing. Through a combination of critical discourse analysis and the poststructuralist approach to narrative theory, the study sheds light on the motivations and consequences of police officers who speak about their individual experiences in the larger sociopolitical discourse of the nation and its policing episteme. The findings of this study contribute to a more comprehensive understanding of police memoirs as a complex and multifaceted genre, offering a deeper insight into the cultural canonicity and tell ability of this ante narrative process. Decoding the stylistic choices, temporal dimensions and the self-censorship of this narrative contestation, the nation's significant and untold history can be brought forth. To do so, texts like *Biting the Bullet: Memoirs of a Police Officer* by IPS Ajai Raj Sharma, *Bihar Diaries: The True Story of How Bihar's Most Dangerous Criminal Was Caught*, and *Life in the Uniform: Adventures of an IPS Officer in Bihar* by IPS Amit Lodha, cater to the purpose of this study by adding an essential layer to the understating of police narrative in the contemporary corpus of cultural studies.

**Keywords:** police narrative, storytelling, counter-narrative, time, memory, transition.





**Moulina Bhattacharya**

## INTRODUCTION

“It was clear that these grievances had to be redressed as soon as possible to raise the morale of the Delhi Police and enhance its performance. Even though I was met with strong resistance, I was able to convince the government about the genuineness of all the three issues.” (Sharma, 114). Policing, as a profession, stands at the crossways of order and disorder, duty and dissent, often veiled in a narrative woven from tales of duty-bound heroism. Amidst this conventional portrayal lies an understated and intriguing aspect—whispered within the pages of police memoirs, where officers reminisce their journeys, struggles, and triumphs. This genre serves as a literary gateway into the intricate world of law enforcement, unveiling narratives that extend beyond the uniform rubrics. Beyond the expected tales of upholding societal norms, there exists a subtle yet potent undercurrent of silent dissent, a narrative resistance that challenges the status quo. This research delves into the multifaceted landscape of police memoirs, seeking to unravel the layers beneath the surface narrative. The conventional portrayal of law enforcement, often associated with duty and adherence to established standards, stands in fabric against the nuanced expressions of dissent and critique found within the memoirs of Indian police officers as these officers navigate the intricacies of their profession, a current of silent dissent emerges, challenging prevailing norms and exposing the ethical dilemmas, institutional flaws, and shades of corruption that persist within the policing landscape. Spanning various regions and historical periods, this study draws from a diverse selection of police memoirs, each contributing to a mosaic of experiences that shape the cultural canonicity of the genre. By employing critical discourse analysis and a poststructuralist approach to narrative theory, the study aims to decode the motivations behind officers' decisions to share their dissenting narratives and the consequences they face in the larger sociopolitical discourse.

This exploration is not merely an academic exercise; it is an endeavor to amplify voices that echo from the pages of memoirs such as *Biting the Bullet: Memoirs of a Police Officer* by IPS Ajai Raj Sharma, *Bihar Diaries: The True Story of How Bihar's Most Dangerous Criminal Was Caught*, and *Life in the Uniform: Adventures of an IPS Officer in Bihar* by IPS Amit Lodha, among others. These narratives add an essential layer to our understanding of policing within the contemporary corpus of cultural studies. By decoding the stylistic choices, temporal dimensions, and self-censorship inherent in these narratives, this study seeks to contribute to a more comprehensive understanding of police memoirs as a dynamic and complex genre. The history of this genre of police memoir might seem new, but it goes way back to the time of the Imperial police in India. The role of the memoirs or, in broader terms, police narrative in the Police Reforms in India is undeniable. Now, the sturdy role of the police and the author is a crucial juxtaposition. They had plenty of dormant narratives in someone's journal, letters, or in their mind that came in light of a published form. Even at present, IPS officers are their accounts and are getting the privilege of publishing them. The credibility of the readership goes to the bureaucratic fame of the Civil Service Exams in this country. But the hierarchical suppression of the subordinate police officers: the constables, sub-inspectors, and inspectors who are the true frontier face of policing hardly cross the boundary of the institutional ground. Do the common people get to know their side of the story? Or if it reached a bricolage of readers, would it make any difference in their sense-making? Counter-narratives are essential tools for rebutting the presuppositions of a dominant narrative framework, allowing for a more nuanced understanding of the complexities and challenges police officers face in their line of duty. Traditional police narratives often present the police as hardworking and diligent officers in challenging situations.

Still, they may leave out crucial context or details contributing to a more comprehensive understanding of the incidents. By examining counter-narratives, researchers can gain a deeper insight into the underlying issues and dilemmas police officers face. Counter-narratives can reveal problems such as corruption, institutional flaws, and moral dilemmas in policing that may not be addressed in traditional narratives. This can contribute to developing more effective policies and practices within the police force. Counter-narratives can create critical social spaces that challenge dominant assumptions and promote social change. By examining these narratives, researchers can gain insights into the dynamics of narrative construction and the power of stories in shaping societal perceptions. Counter-narratives can help us understand the complex interplay of factors contributing to specific outcomes, as seen in cases where the same facts can lead to different stories. This can inform the development of more effective







### Moulina Bhattacharya

strategies for addressing various societal issues. In essence, our journey into the realm of police memoirs is an exploration of the untold narratives. This silent dissent reverberates within the echoes of duty, shedding light on this ante-narrative process's cultural tapestry and tell ability. Through this lens, we aspire to uncover a significant and often overlooked chapter in the nation's history—a chapter written by those who have walked the thin blue line, confronting external adversaries and the complexities that lie within. To study these premises, this research addresses two crucial questions:

1. *What are the consequences (both intended and unintended) of police officers sharing narratives that contest prevailing norms and practices within law enforcement, particularly regarding public perception, institutional culture, and policy discussions?*
2. *How is silent dissent manifested within the narratives of Indian police officers, and to what extent does it diverge from the overt themes of duty and loyalty?*

## LITERATURE REVIEW

This study has followed a brief survey of literature based on key concepts of the research not only of Indian police literature but also its international relationality. The chapter "Silence, Speech, and the Paradox of the Right to Remain Silent in American Police Interrogation" discusses the right to remain silent in American police interrogation, highlighting the paradoxes and limitations of this right. It provides insights into the challenges and complexities of staying silent within police interactions. (Ainsworth) The article "What Studying Nonviolent Resistance Taught Me About Writing Stories That Matter" explores the concept of nonviolent resistance and its implications for storytelling. While not directly related to police memoirs, it offers valuable insights into the power of resistance narratives and their potential to shape social and cultural discourses. (Allagood) The thesis titled "The Hate U Give as Counter narrative: A Rhetorical Site of Competing Frames & the Disruption of Dominant Narratives Through Counter-Storytelling & Homing" explores the concept of counter narratives and the rhetorical action of counter-storytelling, focusing on the disruption of dominant narratives. It provides a framework for understanding the power and influence of counter-narratives in challenging and reshaping established narratives. (Camacho)

In the article "Police as "Helpers": Social Studies Content Standards and Dominant Narratives of Law Enforcement," the authors discuss the dominant narratives of police as a community benefit and the challenges faced in countering these narratives. It offers insights into the potential for counter-narratives to challenge established perceptions of law enforcement. (Kolluri & Young) In his article "The End of "The Right to Remain Silent," Moller discusses the erosion of the right to remain silent within the American legal system. While not directly related to police memoirs, it provides a broader context for understanding the complexities of remaining silent within legal frameworks. (Moller) The essay "Ecotones of Resistance: The Contested Narrative of the 'Refugee' in post-Partition Bengal (1947-71)" elucidates the contested narrative of the 'refugee' in post-Partition Bengal, offering insights into the power dynamics and complexities of resistance narratives within specific historical contexts. (Chakravarty) The book *Counter-Narratives of Crime and Punishment* compares and contrasts the stories of ex-convicts who are actively involved in criminal behavior with narratives of resistance. While not directly related to police memoirs, it offers valuable insights into counter-narratives potential to challenge established narratives of crime and punishment. (Bamberg & Wipff)

## METHODOLOGY

Critical discourse analysis (CDA) was used as a theoretical framework for this research to identify the dominant discourses and power structures within Indian police memoirs. This involves analyzing the language, symbols, and themes that perpetuate the traditional narratives of the police. It helps examine how these dominant discourses marginalize or silence alternative perspectives and experiences within the police force and analyze how counter-narratives disrupt and challenge the dominant discourses and how they provide a platform for the expression of





### Moulina Bhattacharya

silent dissent within the memoirs. The Poststructuralist Approach to Narrative Theory deconstructs the stability and diversity of meaning in the language and narratives of Indian police memoirs. This involves examining how meaning is constructed, contested, and subverted within the narratives. The poststructuralist approach can be used to interpret the motivations and consequences of police officers who present counter-narratives and how these narratives contribute to a more nuanced understanding of the cultural and sociopolitical context of policing in India. It helps analyze how counter-narratives open up new interpretations and understandings of the experiences and perspectives of police officers and how they challenge the traditional canonicity and tell ability of police memoirs. By applying these theoretical frameworks, the research can provide a deeper understanding of the power relations, language, and meaning construction within Indian police memoirs and how counter-narratives disrupt and challenge the dominant narratives, offering a platform for expressing silent dissent within the police force.

#### Silent Dissent In Police Memoirs

Police memoirs that resist traditional narratives subvert expectations by portraying officers who deviate from the expected norms, thereby challenging the established image of law enforcement. Dissent often revolves around an individual officer's clash with institutional practices, as well as the resistant act of the accused or the criminal outlaws, the complaining family, an insurgent mob, and the list goes on and on. The practical police face the lacuna of how they are trained and what they actually face. On top of all those professional obstacles, there is the hierarchical chain of command: For instance, I still remember that after controlling a communal riot in Varanasi, I was summoned by the chief minister (CM), Shri Kamalapati Tripathi at the time, himself a local. He was sitting on the floor and taking minute details from me about the riot which had recently taken place while his attendant was giving him a shave. And after some time, the then prime minister, Indira Gandhi, telephoned him asking for my suspension, as I had taken strong action to control the riot in the CM's constituency. (Sharma, 12) Such circumstantial encounters with political leaders are recurring in their narrative of how that cause puppeteering turns in their professional lives. Memoirs may expose instances where personal values conflict with the broader institutional framework, sparking resistance. Resistance emerges through officers' reflections on ethical dilemmas, moral ambiguities, and instances where personal principles clash with prescribed codes of conduct, presenting a critique of the system. Some memoirs serve as whistle blowing, where officers expose corruption, misconduct, or systemic flaws within the police force, challenging the status quo and advocating for accountability.

Memoirs may articulate dissent by shedding light on systemic injustices within the law enforcement system, addressing issues such as discrimination, abuse of power, and lack of transparency. Dissent can be directed towards leadership within the police force, with memoirs highlighting ineffective leadership, manipulation, or decisions that compromise ethical standards. Resistance extends beyond institutional critique to encompass broader cultural and societal norms. Memoirs may question the role of law enforcement in shaping and perpetuating societal inequalities. Officers expressing dissent may reveal personal struggles, internal conflicts, and emotional tolls associated with their roles, humanizing the narrative and challenging idealized representations of policing. Dissent within memoirs may present alternative perspectives on justice, questioning whether the prevailing legal frameworks genuinely serve the greater good and suggesting alternative visions of a just society. The very structure and style of the memoir can be a form of dissent. Unconventional narrative structures, non-linear storytelling, and experimental forms challenge established conventions, signaling resistance. Memoirs may align with civil rights movements, expressing solidarity with calls for justice, equity, and police reform, contributing to the broader socio-political discourse. Memoirs expressing dissent may aspire to influence policy changes and institutional reforms by bringing attention to systemic issues and contributing to a more extensive dialogue on improving law enforcement practices.

#### Motivations And Consequences

The exploration of motivations and consequences in police memoirs is essential for understanding why officers share their experiences and the far-reaching effects of their narrative choices. Motivations provide insights into the driving forces behind the decision to document and share personal stories. At the same time, consequences encompass the impact (both intended and unintended) of these narratives on individuals, institutions, and the broader sociopolitical landscape. There are some conjectures implied in a varied corpus of such narratives, such as some officers are



**Moulina Bhattacharya**

motivated to write memoirs as a form of catharsis, using the process of reflection and storytelling to come to terms with the challenges and complexities they faced during their careers. A desire for positive change within the police force can motivate officers to share their experiences. Memoirs become a platform for advocating reforms, addressing systemic issues, and challenging the status quo. Motivations can stem from a desire to leave behind a personal legacy or contribute to the mentorship of future generations of law enforcement professionals. Officers may see their experiences as valuable lessons for others. The motivation to document one's experiences contributes to the historical record of law enforcement. Officers may feel responsible for preserving their unique perspectives for future generations. Officers get their motivation to write memoirs as a response to criticism, controversies, or public scrutiny. This allows them to present their story and shape public perceptions. Regarding the consequences, police memoirs can significantly influence public perception of law enforcement. The implications of these narratives extend to shaping how society views the police, either reinforcing established notions or challenging stereotypes. These memoirs can impact the institutional culture within police forces.

Depending on the nature of the narratives, the consequences may include fostering a culture of openness and reflection or facing resistance from within the institution. The consequences of police memoirs may extend to policy changes and institutional reforms. The narratives can contribute to discussions surrounding policing practices, ethics, and the need for systemic changes. Officers may face personal and professional repercussions for sharing their experiences. The consequences may involve criticism from peers, challenges to credibility, or even legal implications, depending on the content of the memoirs. The narratives in police memoirs become part of the larger sociopolitical discourse. The consequences may include shaping public debates, influencing academic research, and contributing to societal discussions on justice and law enforcement. Understanding the motivations and consequences involves examining the delicate balance between authors' intentions in sharing their stories and the broader impact these narratives have on various stakeholders. Exploring the motivations and consequences brings forth ethical considerations surrounding the responsibility of officers in sharing their experiences. It prompts reflection on the potential implications of these narratives on individuals and institutions. Motivations and consequences are not isolated; they represent a dynamic interplay within the narrative landscape. Authors navigate the potential implications of their motivations, and the reception of their narratives influences future motivations. The motivations and consequences in police memoirs contribute to the complex interplay between personal expression, institutional dynamics, and societal impact. Unraveling these threads enhances the understanding of why officers share their experiences and the multifaceted repercussions of their narrative choices.

**Critical Discourse And Poststructuralist Analysis**

Unlike other forms of life-writings, police memoir is equipped with the Foucauldian toolbox of truth, power, and knowledge. The axis of truth here is a composition of autobiographical truth and legal facts. The power dynamic itself is self-explanatory. In this case, the Police is an institution that represents the Repressive State Apparatus of its geo-political body wielding the hand of control. The sense of power draws a line of societal antagonism between police and criminals and creates a new source of knowledge established by the more powerful side to the relatively lesser other. The narrative of criminology, hence, varies on the 'reported' truth. By means of the reliability of the text, this genre itself is narrative non-fiction, and the Oxford Centre for Life-writing suggests, "Life-writing includes every possible way of telling a life-story, from biography and autobiography, through letters and memoir, to bio-fiction, blogs, and social media such as Tweets and Instagram stories." These narratives are the intersection of memoir and fiction since the fictional quality comes from the role play of memory and censorship. Reliability from the readers' perspective is subject to their value judgment and submission to the narrative projection: Determining whether a narrator is unreliable is not just an innocent descriptive statement but a subjectively tinged value-judgment or projection governed by the normative presuppositions and moral convictions of the critic, which as a rule remain unacknowledged. Critics concerned with unreliable narrators recuperate textual inconsistencies by relating them to accepted cultural models. (Nünning, 2008, p. 40) The meaning of the narratives goes hand in hand with the cultural sense-making process. While interacting with the authors or even in their self-explanatory snippets in the larger narrative, it is clearly observable that, in most cases, the motivation behind writing was to let people know their side of the story or the other side of policing where they have written a chronological account of their lives, especially





### Moulina Bhattacharya

etching those events that act as permanent whistle-blowing in the police ears. They even stated that these were the haunting riddles in their mind that made them dig more into the subject, and their life research comes forth as glimpses in the chapters of their memoirs. Research-Based Policing (RBP) is a novel approach for India, which technically goes by the term “Evidence-Based Policing” (EBP) first surged in the U.K., and the U.S. is now earning credibility here as well. However, the episteme of policing in India is still under colonial shadow, and the memoirs are a great vehicle of meta-narration for the historical transition of Indian policing. Each officer's experience is unique as they conduct their own research for their professional/ institutional investigation. Later, they tell their unique stories in a book of memoirs; although the triggering points in their narration might sound similar, their ‘tell abilities’ are different. In the acknowledgment of his book Sharma says, “When I was first thinking of writing my memoir, I was unable to make up my mind to do so, as this thought came to my mind after about twelve years of my superannuation.” (Sharma, 137).

Throughout his book he can be seen to repeat this in several ways, “This memoir is a recollection of events that have shaped my professional journey.” (Sharma, 14). The author of this study, Mr. Lodha states, “In my long career, I have had a number of thrilling encounters, almost all of them etched firmly in my memory.” (Lodha 14). To address the reliability issue he has included a statement in a form of disclaimer: I would like to remind readers that this book is a work of non-fiction. The views and opinions expressed in the book are only mine and do not reflect or represent the views and opinions held by the Government of India. It is based on actual events that took place in my life and drawn from a variety of sources, including published material. It reflects my present recollection of experiences over time as truthfully as memory permits and can be verified by research. (Lodha, 15) Poststructuralist narratology questions the objectivity or stability of various “interpretive structures, including those related to narrative” (Lewis) and challenges the traditional structuralist approach to narrative, which focuses on the formal elements of a story and their relationships. It provides a thick description that delivers detailed accounts of the context and discerns meaning of the narrative. The studied memoirs are the detailed accounts of the police authors and the tales of their lives. The epistemology of the genre in the twenty-first century does not instigate insurgence or Police Reform with direct triggers, but their storytelling harnesses a literary touch of that detailed matrix of the system that stimulates the passive resistance.

#### Cultural Canonicity And Tellability

In the postmodern time of canonical deconstruction, the Euro-centric canon has diverged, but in the canonicity of autobiographies and/or life-writings, where does the genre of police memoirs stand? The targeted readership of this genre is those who aspire to be civil servants and those who are to their job questioning the operational grey zone of ethical policing, I strongly believe that this memoir can also serve as a document for young police officers to learn how, even with a lack of resources, one can successfully perform his or her duty, if the intent is right. (Sharma, 14). On the similar context Lodha puts his opinion: This book is about my journey as an IPS officer. I have truthfully recounted my experiences that helped me become both a better police officer and a better human being. I have had a lot of adventures along the way and, luckily, have been able to learn from them. I am nowhere close to the legends the IPS boasts, nor am I old enough to write an auto biography, but I am hopeful that this memoir of sorts will give the readers a better insight into the life of an IPS officer. Young civil servants, particularly those in the IPS, might find a lesson or two in the chapters. (Lodha, 11)

Understanding the cultural canonicity and tell ability within the context of police memoirs involves exploring how these narratives become embedded in the cultural fabric, shaping perceptions, and contributing to the broader discourse on law enforcement. Cultural canonicity refers to recognizing and accepting certain narratives as influential, representative, or authoritative within a particular cultural context. Tell ability, on the other hand, pertains to the qualities that make a story engaging, compelling, and worthy of being shared or transmitted. Police memoirs can potentially shape a society's collective memory and historical consciousness. Contributing to the cultural canonicity, these narratives become part of a larger narrative about the nation's policing history. The stories told within police memoirs contribute to the construction of societal perceptions about law enforcement, crime, justice, and the role of police officers. The cultural canonicity of these narratives reflects their impact on shaping





### Moulina Bhattacharya

cultural attitudes and values. Memoirs that gain cultural canonicity legitimize particular narratives about policing. They become authoritative sources that influence public opinion, policymaking, and discussions about the nature of law enforcement. The tell ability of police memoirs lies in their ability to engage readers or audiences. These memoirs' narrative elements, storytelling techniques, and emotional resonance contribute to their tell ability. Memoirs that successfully humanize police officers, presenting them as complex individuals with struggles and triumphs, enhance tell ability. Readers are drawn to narratives that transcend stereotypes and offer a more nuanced understanding of the profession. The tell ability of police memoirs often involves a delicate balance between creating narrative tension and providing resolution.

Engaging storytelling keeps readers invested, while resolution offers a sense of closure or understanding. The interplay between cultural canonicity and tell ability influences the broader cultural impact of police memoirs. Those narratives that achieve both recognition as canonical and tell ability are more likely to influence public discourse and cultural attitudes toward law enforcement. Police memoirs that endure and remain relevant over time contribute to the longevity of their cultural influence. Their ability to resonate across generations enhances their cultural canonicity. Cultural canonicity and tell ability also depend on the diversity of perspectives presented within the memoirs. Narratives that reflect various experiences contribute to a more comprehensive understanding of policing and enhance cultural canonicity. Understanding cultural canonicity and tell ability in police memoirs goes beyond examining individual narratives. It involves recognizing the collective impact of these stories on societal perceptions, historical consciousness, and the ongoing discourse about law enforcement. By exploring the qualities that make these narratives culturally significant and engaging, researchers can gain insights into how police memoirs contribute to a nation's cultural and literary landscape.

### Decoding Stylistic Choices And Self-Censorship

Analyzing stylistic choices and self-censorship within police memoirs is crucial for unraveling the intricacies of narrative construction, the negotiation of institutional boundaries, and the nuanced expressions of dissent. Stylistic choices encompass the deliberate use of language, narrative techniques, and structural elements. At the same time, self-censorship refers to the conscious or unconscious decisions made by authors to withhold certain information or perspectives. Both aspects contribute significantly to the overall texture and meaning of the narratives presented in these memoirs. Examining the narrative voice and tone reveals the author's attitude toward their own experiences and the policing profession. Stylistic choices in voice and tone can range from objective and detached to subjective and emotionally charged, influencing how readers interpret the narrative. The use of imagery and symbolism adds depth to the storytelling. Decoding these elements helps uncover hidden meanings, cultural references, and metaphors that contribute to the overall impact of the narrative. Stylistic choices related to the temporal structure of the memoir, such as the use of flashbacks or nonlinear storytelling, can influence the reader's understanding of the chronology of events and emphasize certain aspects of the narrative. Delving into the language and rhetoric employed in police memoirs reveals the author's persuasion strategies.

The choice of words, rhetorical devices, and linguistic nuances can convey authority, resistance, or ambivalence. They have lucidly written about the censorship while depicting their story. In Lodha's words, "I have deliberately chosen not to write about sensational cases or encounters with criminals. Nor have I gone into the technicalities of policing." (Lodha, 11). Sharma testifies his self-censorship as follows: Some names have been changed to protect their identity, since they have been my informers, and for some, a generation has gone by, and it would not be fair to their children and grandchildren to see them in a bad light. (Sharma, 14) Identifying what is left unsaid or omitted within the narrative involves understanding self-censorship. Authors may withhold information due to legal constraints, personal considerations, or institutional loyalty, shaping the boundaries of permissible discourse. Self-censorship may emerge when authors grapple with ethical dilemmas regarding disclosing sensitive information. Understanding the moral considerations that influence self-censorship adds layers to the analysis. Police memoirs operate within the framework of institutional norms and expectations. Authors may self-censor to align their narratives with prevailing institutional ideologies, avoiding narratives that could be deemed detrimental to the reputation of the police force. Authors may also engage in self-censorship based on considerations of their intended audience. Authors may tailor





**Moulina Bhattacharya**

their narratives to align with audience expectations, whether writing for a general readership, law enforcement professionals, or policymakers. The integration of stylistic choices and self-censorship allows researchers to unveil the subtext within police memoirs. Decoding the interplay between what is expressed stylistically and what remains concealed sheds light on the complexities of the narratives. Stylistic choices and self-censorship contribute to the overall narrative contestation within police memoirs. Authors navigate the tension between expressing dissent and adhering to institutional constraints, shaping the contours of the narrative. Understanding how authors exercise agency in making stylistic choices and engaging in self-censorship provides insights into the power dynamics. It illuminates the degree of control authors exert over their narratives. In decoding stylistic choices and self-censorship in police memoirs, researchers understand how authors navigate the intricate terrain between personal expression and institutional loyalty. Unraveling these layers enriches the analysis, offering insights into the complexities of narrative construction within the context of law enforcement.

**CONCLUSION**

In traversing the labyrinthine corridors of Indian police memoirs, this study has sought to illuminate the often-understudied realm of silent dissent that flows beneath the surface of narratives traditionally associated with duty, loyalty, and preserving the status quo. Through a bricolage of memoirs spanning regions and historical periods, the juxtaposition of silence and debate within the narratives of Indian police officers has been revealed as a nuanced layer of critique and reflection. The counter-narratives unearthed within these memoirs serve as a powerful catalyst for challenging prevailing norms and practices within law enforcement. Corruption, institutional flaws, and ethical dilemmas emerge as focal points, punctuating the narrative landscape with instances that question established paradigms. The voices of dissenting officers resonate as echoes against the uniformed backdrop, disrupting the expected harmony and contributing to a broader discourse on the need for reform. Critical discourse analysis and the poststructuralist approach to narrative theory have been instrumental in deciphering the motivations that propel police officers to share their experiences. The consequences of their narrative choices reverberate within the larger sociopolitical discourse of the nation and its policing episteme. Motivations range from a desire for catharsis and reflection to a commitment to advocacy, reform, and documenting a historical legacy. The implications extend beyond the individual memoirists to influence public perception, institutional culture, and policy discussions.

The findings of this study offer a profound contribution to the understanding of police memoirs as a complex and multifaceted genre. Decoding stylistic choices, temporal dimensions, and self-censorship have not only unveiled the silent dissent embedded within these narratives but have also provided a means to bring forth the nation's significant and untold history. The ante-narrative process, marked by cultural canonicity and reliability, becomes a key to deciphering the complexities of law enforcement and its role in shaping societal values. As we conclude this exploration, it is evident that police memoirs stand as more than personal reflections; they are historical artifacts that bridge the gap between individual experiences and collective narratives. The selected memoirs, including *Biting the Bullet: Memoirs of a Police Officer*, *Bihar Diaries: The True Story of How Bihar's Most Dangerous Criminal Was Caught*, and *Life in the Uniform: Adventures of an IPS Officer in Bihar*, have served as indispensable windows into the contemporary corpus of cultural studies. Their narratives add layers to the understanding of police storytelling, enriching our comprehension of a profession often confined to stereotypes. In the intricate dance of words and silences, these memoirs beckon us to question, reflect, and reshape our perceptions. As we decode the narratives of those who have walked the thin blue line, we contribute not only to academic discourse but also to a collective reckoning with the complexities and contradictions within the realm of Indian law enforcement. The untold stories, the silent dissent, and the nuanced reflections embedded within police memoirs serve as a testament to the power of storytelling in shaping our understanding of the past and influencing the trajectory of the future.







Moulina Bhattacharya

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## Shaping Tomorrow: Unraveling the social construction of Youth in the Digital Age

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### ABSTRACT

Visual culture, including the influence of social media, television, films, and other visual mediums, has significantly impacted the perspective of relationships in today's generation. Ever since the advent of OTT platforms, it has also now become easily accessible for the mass to be a part of popular culture by being the regular audience. The series *Made in Heaven* from Amazon Prime, chosen by the researcher, showcases the ugly reality that lies behind the name of the institution called marriages, especially in India. *Made in Heaven* becomes different by choosing topics from various aspects of the society which has influenced a good number of people to think critically about Big Fat weddings. The topics caste, color, culture, religious faith, queerness, sexuality, power, gender and so on have been dealt in the series graciously as it leaves none unthoughtful. It's crucial for individuals to critically evaluate media representations, maintain realistic expectations, and foster open communication to navigate the complexities introduced by visual culture. Hence the paper explores the extent towards which the Amazon series has influenced people in critically analyzing many aspects followed by weddings across India thereby creating a community wise enough to understand and realize, unlearn and relearn their once trusted ideologies regarding marriages.

**Keywords:** Media, Visual culture, wedding, caste, color, sexuality, queer.



**Fatimah Nilofer**

## INTRODUCTION

For a sustainable and peaceful environment to live-in it is necessary that every country should stay at peace and understanding by sharing the values of brotherhood. India being a country known for its uniqueness in diversity is one such place where people are bound to live with secular thoughts. India's culture shares a broad and complex ideology that encompasses shared beliefs, values, customs, behavior, traditions, languages and art and social institutions. Culture and traditions in our country is the sum total of ways of living built up by a group of forefathers which is transmitted from one generation to another through learning. Indians often share common beliefs and values which include religious beliefs, ethical principles, and moral standards. Anyhow it is unfortunate to note that amidst all of these, the country still witnesses distressing issues regarding caste, color, culture, creed, religious faith, power, gender and so on. While India has a rich tradition of religious and cultural diversity, it still witnesses instances of caste discrimination and the social stigma it brings throughout its history. Efforts to dissolve such discrimination in India involve various initiatives at the government, community, and individual levels. On a global level, when it comes to practicing sustainable developmental goals, destructed peace and harmony will affect the entire ecosystem of brotherhood in the planet. Customs and traditions which are related to religious practices and rituals also need to be well maintained and properly practiced with much patience keeping in mind not to hurt anybody's feelings. They can include ceremonies, celebrations, and rites of a particular faith or community. It's pathetic to note that it is in the name of such few practices, injustices like honor killing and untouchability still exists in a country like India where its citizens claim to be secular in thought.

Visual media is one source which influences the public in framing judgments regarding any such social practices. Media today occupies a major role in society and its ubiquitous presence signifies the enormous potential it has for informing people about everyday issues. Media discourse is the main source of people's knowledge, attitudes and ideologies. Movies and series from visual media has reached and shaped the changing political, social and economic thoughts of today's youth influencing them to nurture themselves for a better understanding and better life ahead. One such media production popular in movie site is *Made in Heaven* directed by Zoya Akhtar which revolves around the rich and elite class of Delhi focusing on the issues which are often closeted in the name of protecting the honor or royalty of a family. Problems like dowry, homosexuality, the search of a 'pure' bride, beauty pageants to look for brides, honor killings, molestation, questionable Indian customs and the class divide of India can be seen in the series to be dealt with the clients and their idea of marriage. The series streaming in Amazon Prime portrays different characters chosen from different walks of life showing the ugly realities behind the Big Fat Indian wedding. Marriage being an inevitable institution of custom prevalent in the culture of India, has been a topic of discussion since time immemorial. Customs and traditions related to marriage such as dowry as one among them has always been a problematic target even now. *Made in Heaven* portrays such topics unhesitant with bold face to Indian viewers showcasing the ugly side of marriage, especially which is prevalent only in India. Nevertheless, it largely garnered positive reviews from critics and viewers alike, and was mostly appreciated for how it handled political themes with a great amount of sensitivity and nuance with continued conversations on topics that are usually brushed under the carpet within most Indian households.

From sexism and misogyny, to conversations around queerness, same-sex marriages, colorism, class and caste differences, and the morally ambiguous lives led by those in the wedding planning business, *Made in Heaven* intended to serve as a criticism of the concept of the marriages in India and succeeded to an extent. The narrative not only addresses these issues but also leaves much space for the viewers for contemplation and self-interrogation about the society, their identity, customs, beliefs and marriage as an institution. The clients of the elite class portrayed in the series, even with their education and privileges, restrict the meaning of marriage to mutual concessions and compromises in the name of honour, money and class. Mainstream Bollywood, as well as other Indian film industries have been actively contributing towards Trans phobia over the past few decades by depicting Trans genders in an extreme disgraceful manner. For the benefit of artistic merit, even the respectful representation



**Fatimah Nilofer**

of transgender usually involved cis gender artists. The material condition of the transgender communities remained unchanged when all the praise and applause were grabbed by the actors. It is in this context where *Made in Heaven* becomes different by casting Dr Trinetra Halder Gummaraju for the role of Meher Choudhary, a post-op transgender woman who works as a production executive within the series. In the episode *The Heart Skipped a Beat*, her character plays a proactive role in correcting all the actively and passively passed casteist remarks by others. Being a savarna ally, Meher Choudhry calls out Tara Khanna (played by Shobitha) for referring Pallavi Menke and her fiancé's savarna wedding ceremonies involving "pheras" as the main wedding and the Buddhist wedding as "Pallavi's wedding". Meher stresses on the fact that how important it is to pay extreme attention while such statements are being made. Despite such bold portrayal of story lines and characters go along the mainstream Indian cinema in order to change certain attitude, it has to be scrutinized whether the Indian perspective about topics like these have attained the change it required or not. If at all the intention of the makers of the series was to critique Indian big budget weddings, it has to be questioned why that the modest Dalit wedding was only dedicated for just half time of the episode in a series where four magnificent nuptial ceremonies were showcased.

Hence, when Menke's wedding which actually dealt with the theme of casteism — a social evil that has been plaguing Indian society for centuries — was wrapped up in less than half-an-hour, the ultimate take away from it was that the show inherently remains Savarna-centric. Pallavi Menke might have been a Dalit character, but she was still played by Radhika Apte who is a Maharashtrian Brahmin. Therefore, even if the stories of Dalit individuals are being included in popular culture, Dalit voices continue to remain absent. Not only is it needed for people of the DBA (Dalit-Bahujan- Adivasi) community to talk about their own struggles, but also for DBA actors to be casted for such roles. Beside these facts, issues regarding skin tone and caste in Indian society are often interconnected. Indian's preference for lighter skin tone stems from their inherent thoughts on casteism as well as Euro-centric ideologies in their mentalities. The fact that *Made in Heaven* over looked the issue of colourism solely focusing the whole episode on casteism is another example of the makers just showing savarna ignorance apart from being savarna-centric. Nevertheless, portraying a Buddhist wedding as a homage to B R Ambedhkar on a mainstream Bollywood platform has to be considered a definite win but casting Radhika Apte, a Maharashtrian Brahmin to play the role was quite unfortunate though. Having a background in a privileged section of the society, most of the content writers get influenced by their roots. It's high time that Indian viewers do have the logic sense to differentiate right and wrong and empathize with the larger social and political reality of the society. If not, this only helps creators get away with inauthentic and problematic representations that escape criticism because they're hidden behind progressive jargon.

In a feminist perspective, the show also unveils characters like Faiza, Tara and Jazz as sexually independent ladies who are actually even more than that. Faiza, a character whom the viewer is unaware whether to pity, to sympathize with or to be angry at. Jazz, the sly girl from Dwarka, with her struggles of fitting in the South-Delhi elite crowd and being the sole bread earner of the family, is strong and vulnerable at the same time. Tara's character has so much depth where she undergoes identity crisis along with struggles of fitting in. Being born in a middle class family and then settling into a rich class creates a nuanced character in her. She was taught by her mother that her beauty was a tool which she can use as a weapon to get married into a rich family circle in order to achieve a better family life as well. Karan, Tara's business partner is portrayed as a gay character who is not ashamed to acknowledging his sexuality though his life is full of 'shame' and secrets. The series also shows the struggle that he had to undergo in the name of family love as he is emotionally blackmailed by his mother who insists him to lead a so called 'normal life' by marrying a woman. It shows how certain culture is deeply rooted in Indian minds where normal family mindsets are not ready to accept individual choices no matter their children suffocate out of their orientation. Though Karan acknowledges his privileges of being an educated upper middle class person, his realization when he had to spend time in jail in spite of his privileged background, is one of the turning points in both his life and the series. In a scene where the 'mehendiwali' is offered money to keep silence for being sexually assaulted by a powerful rich man, Zoya Akhtar truly pin points the dirty politics prevalent in the country where how the powerless



**Fatimah Nilofer**

are exploited by the powerful. The entire situation echoes the power imbalances that women are often victim to. The way Adil, who plays the role of Tara's husband, treats the people who are of lower class is a telling of his class prejudices as well. It is at this point we tend to question the truthfulness of what we visualize through media and other platforms. Most of the lives shown or publicized in social media tend to have a curtain behind their photos and reels posted. We tend to believe marriage as a holy tradition but the series *Made in Heaven* has made our eyes open to see the true color that certain culture holds in Indian culture. The lives of the characters, when viewed on screen seem to be different from ours. Class or caste or color or ideological differences might be the reason behind it. The series has anyhow succeeded in raising questions in the minds of the viewers which undoubtedly are matters to be discussed. Is marriage, our identities, our beliefs, the social conditioning, those cultures are as holy as our upbringing has taught us to believe? Are the customs and culture that what makes marriage a marriage? If not, what makes a marriage? Is it really made in heaven? Casteism in India is a deep-rooted social issue that has persisted for centuries. While there have been efforts to address and eradicate caste based discrimination, it continues to sprout in the country especially when it comes to marriage and job opportunities. Despite being constitutionally abolished, practices like untouchability persist in some parts of the country.

The DBA community still faces challenges in the form of discrimination and exclusion from social and economic activities. Limited access to education, employment opportunities, social stigma and biased treatment are some of the barriers faced by such marginalized communities. Economic inequality is yet another challenge faced by them where in some cases certain traditional caste roles often dictate occupation leading to such disparities limiting social mobility. Though governance policies like reservations are implemented to address such historical injustices in order to promote social equality, however these policies often face criticism and controversy with debates about their effectiveness, fairness and potential for creating new forms of discrimination. Stigma that still exist when it comes to inter-caste marriages has been leading to social ostracism and in some extreme cases violence is shed against the couples who choose to marry outside their caste. Cultural practices and stereotyping associated with caste can only perpetuate discriminatory attitudes only to reinforce the already existing social hierarchies. Hence addressing casteism requires a multi-faceted approach that includes legal reforms, social awareness campaigns, educational initiatives and efforts to promote inclusive economic development. Though progress has been made, it's unfortunate to note that these matters still remain as a topic of discussion and for the sustainable development Goals to be implemented in the globe, it is important to eradicate all such injustices happening around us. Since all the 17 integrated SDGs recognize that action in one area will affect the outcome in others, it is also equally necessary to ensure that progression in the country must balance social, economic and environmental sustainability. Only then one can ensure peace, prosperity and well-being in the entire globe and SDG can be well put into practice.

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## Beyond Boundaries: Migrant Women's Narratives in *The Grapes of Wrath*

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### ABSTRACT

Migrant women and girls face a myriad of challenges and vulnerabilities as they navigate the complex landscapes of displacement. The migration experience often exacerbates existing gender inequalities, exposing women and girls to unique risks and hardships. In John Steinbeck's "The Grapes of Wrath," the condition of migrant women and girls takes centre stage as a poignant and nuanced exploration of the human toll wrought by the Dust Bowl migration during the Great Depression. At the core of the narrative is Ma Joad, a formidable matriarch who becomes an emblem of strength and resilience. Steinbeck's portrayal of migrant women extends beyond Ma Joad, encompassing a diverse range of female characters who face a spectrum of challenges along the migrant route. The project explores how these women face the loss of traditional roles, encounter dehumanising conditions in labour camps, and grapple with the disruption of familial and societal structures. It also delves into the ways in which women support each other, forming bonds that serve as a source of strength in the face of adversity. The women in Hooverville camps and labour environments form bonds of solidarity, highlighting shared struggles and mutual support networks. Amidst loss of traditional roles and the erosion of societal structures, the women in the novel strive to preserve their dignity and humanity. Additionally, it sheds light on the sacrifices made by migrant women, emphasising the toll of displacement on their physical and emotional well-being. Steinbeck's exploration offers a timeless commentary on the indomitable spirit of individuals facing systemic challenges, resonating with themes that transcend historical boundaries.

**Keywords:** *The Grapes of Wrath*, Dust Bowl migration, Great Depression, Migrant women, Ma Joad, Traditional gender roles, Resilience, Adaptation and Survival





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## INTRODUCTION

Published in 1939, Steinbeck's Pulitzer Prize-winning masterpiece depicts the hardships of the Great Depression, following the Joads, an Oklahoma farm family, as they are uprooted by the Dust Bowl and compelled to journey to California. Their struggles against the harsh realities of a divided America, split between the privileged and the disenfranchised, unfold in a deeply human yet grand narrative. The novel explores the clash between the powerful and powerless, portraying one man's fervent response to injustice and one woman's resilient fortitude. Steinbeck's novel, simultaneously a naturalistic epic, a tale of captivity, a road novel, and a transcendent gospel, vividly captures the horrors of the Great Depression while delving into the essence of equality and justice in America. - expand here. It's important to understand The Great Depression and Dust Bowl to appreciate the symbolism of the Joad family. The 1920s were a period of economic growth and life seemed to be full of promises. However following the crash of Wall Street on October 24, 1929, the economic hub of America, the economy failed and money lost value rapidly. This led to the Great Depression which left many homeless. At the same time, the Southern states of America (including Oklahoma, Kansas, Arkansas and Texas) were experiencing an extended sequence of dust storms triggered by drought and erosion. The Dust Bowl, characterized as both a human and environmental catastrophe, were a result of agricultural practices that stemmed from ignorance of the nature of the Great Plains.

Uprooting the tall grasses and reduced rainfall resulted in the land being dried and turning into dust. Feeling the economic pressure the banks forced the tenants out of their lands. Like many others, the Joads too had to leave behind their home. The poor tenant's protests that it was their land with which they had emotional connection fell into deaf ears. The owners even employed people like Jr. Joe Davis, Willy Feeley who were desperate for money and willing to tie hands with them in evacuating the poor farmers from their lands. They smashed the houses of the dissenters and pushed it off its foundations. The sheriffs also patrolled the lands to capture anyone who resisted the bank's orders and remained on their land. Left with no choice, many tenants decided to try their luck in California. California has held a reputation as a land of opportunity since the mid-nineteenth century, dating back to the days of the Gold Rush. The state's allure stemmed from a combination of factors, including a favourable climate, abundant resources, and a visually captivating landscape. For many Americans, California represented a place where fortunes could be made and opportunities were abundant. The state's virtues were often extolled in popular songs and stories, creating a narrative that portrayed California as a promised land. This exaggerated depiction emphasized the state's plentiful attributes, further fueling the notion of California as a destination for prosperity. Notably, folk singer Woody Guthrie believed that the tales of California's sunshine and abundant employment opportunities played a significant role in drawing people to the Golden State.

Although California was also affected by the The Great Depression in the early 1930s, agriculture expanded in the state. Growers in the San Joaquin Valley notably quadrupled their acreage in the mid-1930s, leading to an increased demand for labour. This surge in demand resulted in higher wages for agricultural workers, with California cotton growers paying nearly 50% more for cotton picking compared to farms in the southern plains. Furthermore, the state also offered higher unemployment relief than the southern plains states. Family networks played a crucial role in this migration pattern. Relatives who had previously moved to California in the 1920s and found success encouraged their family members in the southern plains to relocate. The positive word of mouth regarding job prospects, the state's climate, and the availability of relief programs set the migration in motion. The hopeful migrants travelled along Route 66 to California. Almost 100,000 of them chose to live in Los Angeles and the rest, 70,000 chose San Joaquin valley. The city of Los Angeles handled the Great Depression much better than other states owing to its diverse economy based on several industries. The sectors of film, tourism, oil, agriculture, manufacturing, and trade were pivotal in shaping the economic landscape of the region. Among the migrants, those with specific skills found more favourable opportunities. Individuals with experience in aircraft and auto assembly, in particular, had promising job prospects. The construction of the Boulder Dam also emerged as a significant source of blue-collar employment. Conversely, migrants lacking specialized skills faced greater challenges. For them, reliance on personal connections, often facilitated by family members, became crucial in navigating the competitive job market.



**Aleena Babu**

However life in the valley was quite different. The fertile valleys produced over half of the nation's oranges, grapes, walnuts, carrots, and lettuce. The agricultural landscape was largely dominated by large commercial farms that specialized in a few crops. These farms relied on a seasonal labour force that arrived during harvest time and dispersed once the crops were gathered. Mexican farm workers played a crucial role in meeting the demands of this cyclical lifestyle; they would work in the harvest season and then go back home in the winter. The challenging times of the Depression disrupted this established system. Stringent immigration laws led to the forced deportation of thousands of Mexican workers. Their absence created a labour void, attracting Dust Bowl migrants to settle in California's farm valleys. The great influx of migrants throughout the 1930s overwhelmed local and state infrastructures. They vied with the local residents for employment opportunities, accepting lower wages and disregarding picket lines. Many were also turned away at the borders. Migrants fortunate enough to secure employment quickly realized that the abundance of workers led to a substantial decline in prevailing wage rates. To survive, women and children too took up jobs. Children as young as 7 or 8 worked in the fields and earned 78 cents picking cotton. Although a meagre amount, it helped their families survive. Even with entire families contributing to the workforce, it became impossible for migrants to sustain themselves on these diminished wages.

During the 1930s in America, women predominantly occupied domestic roles, often overseeing home management and social responsibilities. Men, on the other hand, were typically the primary earners for the family. In the 18th century, women in tenant families in Oklahoma, as in many agrarian societies, were integral to the functioning of the household and the overall agricultural operation. They were primarily responsible for managing the household and played a central role in ensuring the well-being of the family members. Throughout the course of the novel, women take on more than their traditionally ascribed roles and become the pillar of strength and support the family needs as they go through dire circumstances. When the destructive forces of the Dust Bowl had taken over the once fertile green fields of corn and left them dead and dusty brown, the women played their part as caretakers and offered their silent support to their men. The men weren't worried that the women would break as they often displayed strength and resourcefulness when dealing with agricultural hardships. As primary caretakers of the family, women knew that everything was alright and there was hope for the future as long as the men didn't let down their hopes and stood helpless at the loss of crops.

"After a while the faces of the watching men lost their bemused perplexity and became hard and angry and resistant. Then the women knew that they were safe and that there was no break. Then they asked, What'll we do? And the men replied, I don't know. But it was all right. The women knew it was all right, and the watching children knew it was all right. Women and children knew deep in themselves that no misfortune was too great to bear if the men were whole." (Steinbeck 3-4) The women are gratified that the men don't lose sight of the future as they are to lead the family. The men's utter disregard towards any concerns women might have, although concerning, isn't surprising as it was expected of them to be pillars of support that hold the family together in hard times. They take on their roles gladly lest their family fall apart. Thus they conceal their fear and leave them unacknowledged so as to protect their family. "And since old Tom and the children could not know hurt or fear unless she acknowledged hurt and fear, she had practiced denying them in herself. And since, when a joyful thing happened, they looked to see whether joy was on her, it was her habit to build up laughter out of inadequate materials." (Steinbeck 50)

Women are also not encouraged to be one who makes decisions of any kind - it's reserved for the man. When the landlords demand the tenants to move out of their land, the women stay behind with the children anxious but silent. "In the open doors the women stood looking out, and behind them the children — corn-headed children, with wide eyes, one bare foot on top of the other bare foot, and the toes working. The women and the children watched their men talking to the owner men. They were silent." (Steinbeck 31) Their fidgeting, shifting legs shows their desire to be a part of the discussion that affects them equally. Things take a turn with the introduction of Ma Joad, the central character around whom the events of the novel unfurl. She is the pillar, the citadel of the family that holds it together. She can be considered as a representative of all migrant women who took on more than their traditionally ascribed roles in the face of labour deprivation and abject poverty the Dust Bowl migrants faced in California. Economic hardships and family survival necessities compelled women to take on roles traditionally ascribed to men.



**Aleena Babu**

This shift in responsibilities arose from the urgency to meet basic needs in the face of poverty and limited job opportunities. Women assumed leadership within families, adapted to changing dynamics, and played crucial roles in community building within migrant camps. Ma Joad's subjective identity exhibits certain traits aligned with conventional gender roles which evolves through the course of the novel. She is first seen in the kitchen welcoming Tom and Jim Casy for breakfast even before knowing their identities. It is also Ma Joad who looks beyond the preacher Jim Casy used to be and values the guidance and moral support he could provide on their arduous journey. When Pa expresses his hesitation to include him on their journey emphasising the lack of space and extra mouth to feed, Ma stands her ground and says "I have never heard tell of no Joads or no Hazletts, neither, ever refusin' food' shelter or a loft on the road to anybody that asked. They's been mean Joads, but never that mean." (Steinbeck 102) As representatives of the Dust Bowl migrants, the Joad family has all their hopes pinned on California. While all the Joad men are excited and hopeful, it is only Ma Joad who expresses her concern whether it is all false. But she consoles herself thinking that no would waste their money on the pamphlets if the information was false. Her worries come true when they reach California.

On reaching the Hooverville camps, Ma gets a firsthand understanding of the systemic hardship and reality of the employment opportunities publicised to be true in the promised land. In the camps, the impoverished migrants lived in squalid conditions. It is a microcosm of the Great Depression and economic hardships faced by a majority of the population in California. Upon seeing the camp, Ma Joad worries about the food shortage of her own family and the camp as a whole. She feels helpless when she's unable to give a helping hand to the starving children. "I dunno what to do. I got to feed the family. What'm I gonna do with these here?" (Steinbeck 269) As the novel progresses, in the face of continued hardship, Ma Joad becomes resilient and takes on the role of the head of the family. This is a slow progress which began enroute to California. As the Joads were crossing the desert near California, Grandma Joad passed away. However Ma holds the news to herself in order to prevent making a stop in the desert as it could be dangerous to the vulnerable members of her family - two young children and pregnant daughter. When passing an Agricultural inspection station, Ma Joad makes a false claim that there's a sick old woman awaiting treatment to stop them from checking their truck. Ma assumes responsibility and calmly manages the accident with wisdom and decisive actions. Later on in the novel when the Wilson's car breaks down, Tom and Casy offer to stay behind and fix it and suggest his family move ahead. Pa is in favour of the decision and wishes to continue their journey, anxious to reach the promised land. However Ma takes a firm stand and refuses out of fear that the family would become divided when they should stay together in this tumultuous situation. She confronts her husband with a jack handle and expresses herself in the language traditionally associated with men. "I'll knock you belly-up with a bucket. I swear to Holy Jesus' sake I will" (Steinbeck 169). The open defiance, explicitly identified as a rebellion, marks the pivotal shift in leadership within the Joad family's journey. It is Ma who realises much earlier than anyone that once the family splits, it can never come again together. Contrary to everyone's expectations, Pa relinquishes his control in a non violent manner believing it to be temporary.

Anger serves no purpose, and Ma has assumed the position of authority. Anger becomes vital and sustaining as the prospect of work and security dissipates swiftly, akin to the pamphlets carried away by the wind. Ma takes full command of the family's emotions when she determines it is time to depart from the security of the government camp and venture into uncertainties elsewhere. When Pa sarcastically comments that times have changed and now women are in control, Ma riles him up further by saying men have the right only when they can put a roof over his family's head and food in their stomach. As Pa ultimately gives in to despair, expressing, "seems like our life's over an' done," (Steinbeck ) Ma shifts her approach. Instead of provoking him to anger, she transforms into a wise nurturer, adapting her role within the family to meet the emotional needs of the men. She states that, "man, he lives in jerks – baby born an' a man dies, an' that's a jerk – gets a farm an' loses his farm an' that's a jerk. Woman, it's all one flow, like a stream, little eddies, little waterfalls, but the river, it goes right on." (Steinbeck 423) In the concluding pages of the novel, Ma Joad characterizes her role by likening herself to the earth and water—a relentless force that can adapt to the constraints imposed upon it. Consistently, Ma Joad moulds Rose of Sharon into the woman she must become to eventually aid her family's survival, underscoring that mere pregnancy does not inherently transform a girl into a woman. Throughout the novel, Rose of Sharon remains in the shadow of Ma Joad, an untested



**Aleena Babu**

woman navigating the complexities of her first pregnancy, learning the essence of womanhood through her mother's resilience. The final chapter initiates the anticipation of new life as Rose of Sharon begins labour. While women assist in the labour, the men engage in unpaid labour to construct a levee against the rising river. She gives birth to a still born who symbolises the inability of new life to flourish, representing a failure in one of women's fundamental roles. Despite this, Rose of Sharon expresses only one line of despair, "the girl lay back again, and covered her eyes with her arms." (Steinbeck 449) This response demonstrates strength—an inherited ability to shield women's despair from the scrutiny of men. This serves as evidence that Rose of Sharon has acquired a profound understanding of womanhood within the cultural context in which she will live. As she cannot nurture and sustain a new life, Rose of Sharon feeds a starving middle aged man, fulfilling her duty as a woman by nurturing men even in the absence of children. The complete loss of dignity in the final pages of the novel are accompanied by an intense swell of humanity, Rose of Sharon gaining the courage of her mother, concealing her own inner grief, taking control of emotion so that life can continue.

"She looked up and across the barn, and her lips came together and she smiled mysteriously." (Steinbeck 618) Her smile echoes her earlier "sly smile" (Steinbeck 134). By examining these distinct smiles, we discern Rosasharn's evolution beyond her previous self, embodying increased strength, optimism, and humanity. Through aiding others, she ultimately discovers her intrinsic value and secures a sense of female subject identity. In this way life continues. In *The Grapes of Wrath*, John Steinbeck depicts a family that represents the thousands who endured the hardships of the darkest decade of the twentieth century. The novel doesn't aim to dissect the familial dynamics of Dust Bowl migrants but rather to present them authentically, as individuals with a history and a way of life they sought to preserve, not reinvent. The restructuring of the family that unfolds in the narrative is a response to the urgent need for preservation, fueled by the belief that displacement is a temporary setback and that the familiar aspects of life will eventually return. Within this male-centric framework, Ma Joad epitomises womanhood—a force that remains silent during prosperity but emerges forcefully in times of adversity.

Confronting significant changes, women surpass men in various aspects, echoing Ma Joad's assertion that "woman can change better'n a man... woman got all her life in her arms. Man got it all in his head" (Steinbeck 442). Transitioning from initial silence to later gaining negotiation rights and even assuming a form of "leadership," Ma Joad's female subject identity undergoes a reconstruction. Consequently, the westward migration becomes a process of forging a new subject identity; Ma and Rose, throughout their travels discover their opinion is just as important as a man's. Their maternal instincts thrive, and they become a powerful source. In contrast to the male figures falling apart due to new surroundings, Steinbeck shows that through the Depression there is an equal opportunity of both roles, as the male authority weakens which creates strong-minded female characters rising to the challenge and portrays an extremely weak American patriarch. As patriarchal ambitions in financial gain were a major contributing factor to Depression-era society's failings, Steinbeck recognised that the mother had to take on the role of leader to restore American society to its "social origins." Steinbeck's understanding of "the primitive ascendancy of women is founded not on economic power but on the constitutions of the social group" (Briffault 96) is what makes Ma Joad the only one who can successfully carry out Steinbeck's theme of "group survival." Because she is a mother and because "human society developed" and initially survived due to maternal and "female instincts only," Steinbeck believes that Ma Joad is "valuable to society" (Working Days 70).

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**Aleena Babu**

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## Revolutionizing Healthcare Delivery: An Integrated Approach to E-Health Donation Oversight, Nutritionist Support and IoT Services

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### ABSTRACT

In the present situation medicine donation is highly important there by increasing the efficiency and decreasing the medicine like liquid, tablet, capsules, creams, lotions or ointments, suppositories, drops, inhalers, injections, implants or patches information to work load. The system has been developed under web forms environment for medical and NGO. In this forms, medicine and dietician follow-up records would be easily handled. User can navigate the donation requested and sponsor responded for that medicine record as per the user requirement. The input screens are very user friendly and most of data is validated during data entry itself and hence the time is saved. It is efficient to retrieve the data from stored database. At present the dietician follow-up table information system and its all procedures are totally manual based. It creates a lot of problems due to wrong entries or mistakes in totalling for patient food and supplementary etc. This system avoided such mistakes through proper checks and validation control methods in checking of medicine before and after diet follow-up table through IoT services. This system provides about the NGO group information, Donator/Sponsor information, Medicine resources information, Community member information, Doctor consultation information, Dietician plan information, Treatment Diagnosis information, Medical Camp information, Donator/Sponsor payment information, Medicine delivery information and Dashboard update information. The study aims to provide insights into the multifaceted integration of E-Health, donations management, nutritionist expertise, and IoT advancements, fostering a new era of efficient, patient-centric healthcare delivery.







Sivakumar

**Keywords:** Medicine, Dietician, Donation, NGO, Machine Learning (ML), Artificial Intelligence(AI), Internet Of Things (IoT), Web Application.

## INTRODUCTION

This project entitled “Revolutionizing Healthcare Delivery: An Integrated Approach to E-Health Donation Oversight, Nutritionist Support, and IoT Services” has been developed to make a website for medicine donation supervision information and community service system. India has made rapid strides within the health sector since independence. Nonetheless, multiple NFHS eye-opening data clearly show that access to healthcare is still a problem. While rural India's health statistics are still poor, the health status and access to health for the poor in urban slum residents have emerged equally deplorable and have but 4% of presidency primary healthcare facilities[1]. NGOs are playing a significant role in modern India. The numbers of NGOs have increased over the past two decades. They are running parallel to government organizations and supplementing the activities of the government. Medicines are an essential element in alleviating suffering, and donations of medical supplies will greatly benefit international humanitarian relief efforts[2]. This medicine donation supervision system is about the collection of medicine which is unused by the patient who recovers completely and remaining medicines becomes waste, those medicine can be collected and used further. This remaining medicines can be used by NGO's, Hospitals who are indeed for those medicines. By use of this application there will be less wastage of medicines. A donation of medicine, when well organized and controlled, can save lives and ease the suffering. Effective donation practices can provide savings in budgets for development support, so that these services can be used for other purposes.

The "Non-Governmental Organization-NGO" program serves as a bridge between an immense network of medication donations and NGO 'S, Orphanage, Old Age house[4]. A NGO is a non-income-driven organization autonomous of States and all-inclusive administrative organizations. They are usually sponsored by blessings, yet some completely avoid formal funding and are run by volunteers in essence. Users of smart phones have increased rapidly in the last one or two years and counting is still on it becomes very easy for users to use the android app. As the system realize there are many current donation sites for medicinal items, they are not up to the standards and require more manual data handling. The system is developing new and upcoming image processing technologies to overcome this problem. With this technology to solve all the above-mentioned problems and have a very user-friendly application. “Revolutionizing Healthcare Delivery: An Integrated Approach to E-Health Donation Oversight, Nutritionist Support, and IoT Services” is a community member forum of India for NGO is responsible for responding to sending medicines through NGO-Members non-profit and proprietary. While the medicine donation has never-ending authority over panchayats, villages, town, cities and metro-cities, after reviewing the submitted requests for medicines from community members. This system focuses the website users to create a common gateway to the data and services that the people throughout international wide need to effectively share information and work together. NGO portals can be built on technologies based on the website.

### Purpose

This system comprises of use of left-over stuff or item which can be used by poor one. Application will be the total tolerating stage for the things which individuals need to give without login into another destination. Likewise, this site comprises of the various required rundown from number of NGO-Admin which will acknowledge our member's gift. Member will have the full track of their package. This system donation is the one of the medical facilities to serve the people of certain population for their healthcare. Before this, system uses the manual system to manage the medicine delivery through courier. It needs the pharmacist assistant check the medicine twice a week to check expire date of the medicine in the storage and the medicine that out of stock[3]. The pharmacist assistant take out the medicine that rise the expired date and keep it at the safety place to avoid mistake the expired medicine to be sell. If there is the stock of the medicine, that is sent to NGO-Admin by sponsor/donator. The main aim of this system is to filling by the NGO-Admin to request the medicine from the medicine company and donator/sponsor. The





### Sivakumar

manual system that use is not very reliable to the today. Therefore, the new approach of E-Medicine donation system application is needs to make the more efficient and effective[5].

#### Scope

The scope of this system is project scope will define the boundaries of “**Revolutionizing Healthcare Delivery: An Integrated Approach to E-Health Donation Oversight, Nutritionist Support, and IoT Services**”, which includes system functionality, users and operating location/availability. Community members are joined in this NGO-Group and classifying the medicine relate to the symptoms that occur. The other function in this system is adding, delete and update medicine from the requested list and class of the medicine[1].The main aim will process the function to select community member requested medicine as per doctor consultation and the suitable medicine depend on the information that match with the symptoms for that treatment diagnosis to find the disease. Record the medicines and by the NGO-Admin that requested to the donator/sponsor. NGO-Admin can conduct the medical camp for the NGO-members[4],as per doctor consultation members are advised to treatment diagnosed from the medicine resources and plan the diet for follow up table to medicine delivery reports are maintained for every updates in the dashboard. NGO-Admin can only do the process like medicine receiving process from the sponsor, view medicine stock, and list the medicine. The NGO-Admin can only display the list of medicine and the map of pharmacy[5].

#### Objectives

The main objective of this “Revolutionizing Healthcare Delivery: An Integrated Approach to E-Health Donation Oversight, Nutritionist Support, and IoT Services” system is to take the whole NGO-members online so that it is reachable to quickly. It also aims at going towards donations and contributions. It will impart a wider visibility to the NGO-members. Thus boosting the business to higher levels[4]. The system will be a web based system with a very user friendly interface which indeed will make the whole donation supervision system process IoT services is easy to manage and NGO operate with zero redundancies. Overall this system will become an efficient, highly responsive and an extremely accurate system.

1. Function to listing the medicine that relate to the minor illness like cough, fever, and flu.
2. Handle for the new NGO-members registration to be the authorized user in application.
3. Display the statistic for medicine donations in bar graph visualization.
4. Display the medicine received from the donator and statistic to show the total items in NGO-medicine requirements for each medicine.
5. Provide the report to display the medicines & diet plans that want to be maintained in the follow-up table.
6. Responsible to monitor the medicine stock alert warning by the IoT service.
7. Provide the list of suitable medicine and the advice from expert doctor consultation.
8. Check the analyst of the frequency of the disease with the help of treatment diagnosis.
9. Responsible in select the suitable medicine for minor illness by the NGO-members only.
10. Control the information of the nearest NGO-Group take place.
11. Tell the doctor at the consultation about the symptoms by the NGO-members
12. Operating location availability NGO-Group.
13. Available to arrange at all type of pharmacy items in NGO-Group.

#### LITERATURE SURVEY

This section provides an overview of existing research related to system analysis phase is the definition of the problem that defines at planning phase. NGO-Group Admin, pharmacist and system developer identify the process of the “Revolutionizing Healthcare Delivery: An Integrated Approach to E-Health Donation Oversight, Nutritionist Support, and IoT Services” system. It also needs for study the user requirement and the manual system. The result is logical data design. It is the specifying the conceptual data model, inputs, processes, and expected output requirements. This system has eleven modules or processes that to be function. The logical design is describe using data flow diagram, DFD and entity relationship, ER diagram, ERD. The results of the logical design are entities,



**Sivakumar**

attribute and the relationship of the entities within the database. It also describes the function of modulus for each process within the database environment. The users that involve in the system are pharmacist, NGO-Admin and customer. It is the most creative and challenging phase of the system life cycle. The analysis phase is used to design the logical model of the system whereas the design phase is used to design the physical model. Many things are to be done in this phase. The proposed system began the designing process by identifying forms, reports and the other outputs the system will produce. Then the specify data on each were pinpointed. The system sketched the forms or say, the displays, as expected to appear, on project, so it serves as model for the project to began finally system design the form on computer display, using one of the automated system design tool, that is ASP.NET(C#) After the forms were designed, the next step was to specify the data to be inputted, calculated and stored individual data items and calculation procedure were written in detail. File structure such as paper files were selected the procedures were written so as how to process the data and procedures the output during the programming phase. The documents were design in the form of charts .Output design means what should be the format for presenting the results. It should be in most convenient and attractive format for the user. The input design deals with what should be the input to the system and thus prepare the input format. File design deals with how the data has to be stored on physical devices. Process design includes the description of the procedure for carrying out operations on the given data.

**Existing System**

The existing system comes standard with a very long list of included features, however in order to help their NGO-Members make the business more successful the system offer many additional services like website search engines submission and promotion, and marketing services. The existing website portal that provide the e-commerce website and system. The existing system has providing services, but no website search engines submission and promotion and NGO-Services. The existing modules are covered product management, orders and accountancy, automatic prescription generation, back office user management, credit cards functionality, medical questionnaire, website management, statistic, history and security, affiliates functionality, and control and notification. The descriptions of the modules are explained in two paragraphs[4]. First, product management. This module perform to bulk product categories insert functionality or multiple ways to manage and upload product images. It also define product and marketing categories, assign one product to more than one category, set a marketing, prescription or handling fee in percentage for every product and many other features extremely suitable in the case of online. The existing system is not contain any NGO or NGO portal[5].

**Drawbacks Of Existing System**

1. The existing system is not voluntary associations which are created by people having a common interest.
2. The autonomous bodies free from the interference of government. They are regulated by their own policies and procedures.
3. The existing system not profit making business organization. Rather they show a lot of concern in social welfare aspects such as education of children, protection of animals, wildlife, environment, improving the status of women etc.
4. The existing system create and maintain their own funds. They often collect contribution from the public. Some NGOs are also financed by private business organization. Some NGOs are also financed by international authorities.
5. NGOs take up activities such as the provision of health, family planning or education services and not concentrate any E-Medicine concept.

**Problem Discussion**

The define problem and constraint is the problem definition process might initially appear to be unstructured. NGO-Admin are often unable to describe the larger scope of E-Medicine operations precisely or to identify the real problems encountered during NGO-Admin operations. Define objective is a proposed database system must be designed to help solve at least the major problems identified during the problem discovery process[2]. First, selecting



**Sivakumar**

the suitable medicine for the type of illness is usually take time and makes the patient or NGO-Member waiting. Therefore, the time is waste for the NGO-Member to be waiting. Second, for the E-Medicine, the pharmacist must check it manually and no warning message for the medicine that decrease to finish. So, E-Medicine provide the advantage to setup the process in selecting and alert program to warn about the medicine stock[5]. Finally yet important, no analyses are done for the frequency type of medicine usually buy by the NGO-Member or patient at that area. This is also important to determine the medicines that are demanded more from the NGO-Member so that pharmacist can be prepared to requested from the sponsor more for that type of medicine[4].

**Proposed System**

Nowadays, The proposed system as a common platform for multiple types of donation are received in our NGO-Portal. This application comprises of use of left-over stuff or item which can be used by poor one. Application will be the total tolerating stage for the things which individuals need to give without login into another destination. Likewise, this site comprises of the various required rundown from number of NGO which will acknowledge our donator's gift. Donator will have the full track of their package. Medicine donations in collaboration with major international donator from the various organizations involved in humanitarian relief and development assistance. The Guidelines aim to improve the quality of donations of medication in international development assistance and emergency aid[1]. As good medicine donation practice is of interest to both donors and recipients. The dietician assistance is an web based application. In this system, there are three entities, NGO-Admin, NGO-Members , and Donator/Sponsor[5]. NGO-Portal group admin can post available medicine with the medicine name, medicine description, QR code, and medicine expired date. In this process, the NGO- Members should have register and start with the login process. NGO- Members will verify by login process gateway[4].

NGO- Group Admin can open previous donation records. NGO- Group Admin will view status i.e. NGO- Group Admin is arriving or not and also medicine will assign or not. On the admin side, they can see all NGO-Admin, NGO-Members , and donator/sponsor details and also see all the medicine types. Admin is the main part of this system. Admin approves NGO-Members requests because without approval NGO-Members cannot log in. NGO-Admin select NGO-Members and assign respective medicines [5]. The NGO-Members volunteer registers and waiting for approval because without NGO- Group Admin approval they cannot log-in in this system. When NGO- Group Admin assign the medicines to NGO- Group Admin, can open the NGO- Members address location and go to that location and give the requested medicines. In this system NGO-Admin, NGO-Members, and Donator/Sponsor is used for local database used for connectivity between database and web based application to IoT services[3].

1. Guidelines for medicine donations revised world health organization.
2. Guidelines for medicine donations in revised pharmaceutical preparations for supply and distribution.
3. Essential drugs for supply and distribution to NGO-Portal.
4. Relief work to NGO-Portal Members.
5. Emergencies to NGO-Portal for E-Medicine system.
6. Inter NGO-Portal service relations for serving to the overall NGO-Members.
7. Guidelines for NGO-Members health is watched by every time.
8. Provides the plan for NGO-Members dietician plan with the help of follow-up table as per doctor consultation.
9. The proposed system is designed to overcome all the disadvantages of the existing system.

**MATERIALS AND METHOD**

The methodology used in this project is evolutionary prototyping. A requirement gathering will be performed to gather the initial specification of this project. In this project, questionnaires and interview are used to collect data from NGOs, medical centres and the public[1], which the users of this mobile app. At present the dietician follow-up table information system and its all procedures are totally manual based. It creates a lot of problems due to wrong entries or mistakes in totalling for patient food and supplementary etc. This system avoided such mistakes through



**Sivakumar**

proper checks and validation control methods in checking of medicine before and after diet follow-up table through IOT services. Data collected are transformed into project specifications. The prototype is built to Azure RP 9. Users' evaluation based on the project specifications is carried out. The developer refines the prototype to a better version according to users' feedbacks. Iterations for design, build prototype, users' evaluation, and refinement of the prototype are carried out until the prototype developed satisfies users[5]. The medical equipment and medicine recognition will only focus on 10 medical equipment, including commode, wheelchairs, walking frame, blood pressure set, breast pump, thermometer, rippled mattress, oximeter, crutch and therapeutic ultrasound machine. Deep learning models implemented are Inception-v3, ResNet-50 and VGG-16. The similarity of the nine apps can be categorized into low, high and very high. Image data sets for medical equipment, including commodes, wheelchairs, walking frames, blood pressure monitors, breast pumps, thermometers, rippled mattresses, oximeters, crutches, and therapeutic ultrasound machines, are collected for training and testing of the deep learning models. Besides, a grid search method is used to find the best combination of hyper parameters such as optimizer, batch size, epoch number, dropout rate, and learning rate. The deep learning models have successfully addressed and solved the limitations faced by traditional machine learning models. Inception-v3 outperformed the other two models with the highest accuracy of 0.9372 when testing with photos uploaded by the users[1].

**Implementation**

Implementation is the stage, which is crucial in the life cycle of the new system designed. The implementation phase is starting at process installing software and hardware and requirements. Installation hardware is setting up the PC desktop hardware requirements specification. Process of operating system installation is base on Windows 8 installation [1]. ASP.NET (C#) as front end and SQL-SERVER as back end are installing following the steps that required. These scripts are type in proposed system application development. This will be testing and debugging, until it is ready to be delivered. The actual database is created and customizes the tables and view, and user authentication[3]. The proposed system aims to address challenges faced by NGOs, medical centers, and the public in reducing medical waste and fostering a zero-waste culture. The proposed solutions target NGOs/medical centers, the public[3], and administrators involved in the donation process[5].

**Donation Platform**

The project suggests creating a platform that allows the public to donate medical equipment in good condition to NGOs or medical centers[1]. This initiative aims to significantly reduce waste and prevent the environmentally harmful disposal of usable medical equipment. NGOs or medical centers can review a list of equipment that members wish to donate, and verification processes can be implemented to ensure the donated items meet the required standards[4].

**Medical Equipment Recognition**

To streamline the donation process, members can utilize a scanning feature to register the medical equipment they intend to donate. Deep learning models, including Inception-v3, ResNet-50, and VGG-16, would be employed for medical equipment recognition, ensuring accuracy and efficiency in cataloging donated items[5].

**Education on Donatable Items**

Recognizing the low awareness levels among the public regarding proper medical equipment disposal[1], the project proposes an educational component. Members will receive information guiding them on distinguishing between equipment suitable for donation and items that cannot be donated[5].

**Search for Donation Drop-off Points**

Given the lack of awareness about medical equipment donation, a feature enabling users to search for NGOs or medical centers accepting donations will be implemented[5]. This search functionality aims to encourage and facilitate donations by making drop-off locations easily accessible to the public





**Sivakumar****Pickup Service**

To further simplify the donation process, members can request a pickup service. Personnel designated for this task will collect donated items directly from the member's location, providing convenience and encouraging more people to participate in the donation initiative.

**Communication Channel**

The project envisions a chat engine facilitating communication between the public and NGOs/medical centers. Recognizing the public's limited knowledge about medical items, the chat box feature allows members to ask questions directly to NGOs or medical centers[5]. This communication channel aims to streamline the donation process and address any concerns or queries members may have, fostering a collaborative and informed approach to medical equipment donation. The testing process is to be doing to test the system application operation. After testing is concluded, the final documentation is reviewed and printed, and end users are trained[3]. The system is in full operation at the end of this phase but will be continuously evaluated and fine-tuned[5]. The implementation phase NGO manages the stock which helps to maintain the record of the available medicine. In case of security NGO can also change their password. Members can register and login using credentials. They can donate medicine by providing medicines detail and raising request, further it will be approved by admin, they will schedule the donating date. Members can also check their previous data of medicine transactions. Maintenance phase is involve when the proposed is used in several times, there are the changes of the proposed system is to be request by the NGO-Admin[5]. The changes generate the system maintenance activities, which can be grouped into three types, corrective maintenance in response to system errors, adaptive maintenance due to changes in the business environment, perfective maintenance to enhance the system. For the NGO's activities maybe include these three (3) maintenance activities which is, NGO-Admin want to add the module or delete the module of the application.

**RESULTS AND DISCUSSION****Product**

To develop a system application based on the functionality and usability of the mobile applications, and medical equipment recognition.

**Idea**

A mobile application to recognize unused medical equipment for three entities: NGOs/medical centres, member and admin has been developed. This mobile application eases the donation process between NGOs/medical centres and members. It encourages the public to donate their unused medical equipment. The donated medical equipment can be reused and recycled to reduce medical waste. The system requirements gathering are the first step to gather information from targeted users. Methods used for requirement gathering are qualitative and quantitative. Background study on medical equipment and medicine that can be donated and reused is carried out. Literature review on similar application, software methodologies, frameworks and object recognition approaches are conducted. After understanding the background, requirements are gathered from NGOs, medical centres and the public. Use case modelling such as use case diagram and use case descriptions are designed to illustrate real life scenarios in stakeholders' view[4]. Gantt chart and Work breakdown structure are used to control the project schedules completed within the timeframe and scope[5].

**CONCLUSION**

Modern era has begun. People both privileged or unprivileged, literate or illiterate are now conscious about their health. It is a matter of sorrow that being conscious poor people cannot pay much attention to their health care routine because of their low income. NGO's take great initiative by providing free treatment to needy people[1]. But most of the cases, they get the treatment of expensive medicines. Therefore, this great initiative become value to them. This system provides a brief overview of the design and development of IoT application, which will be very







**Sivakumar**

effective and will bear great contribution to get the health services for these needy or login come people[2]. Due to this application even wastage of medicine gets reduce. The main objective of this system is to provide a set of medicine donation guidelines that will guide recipients and donors through the donation process. The intention is to improve the quality of medicine donations in development and emergency aid[3].

**Future Scope**

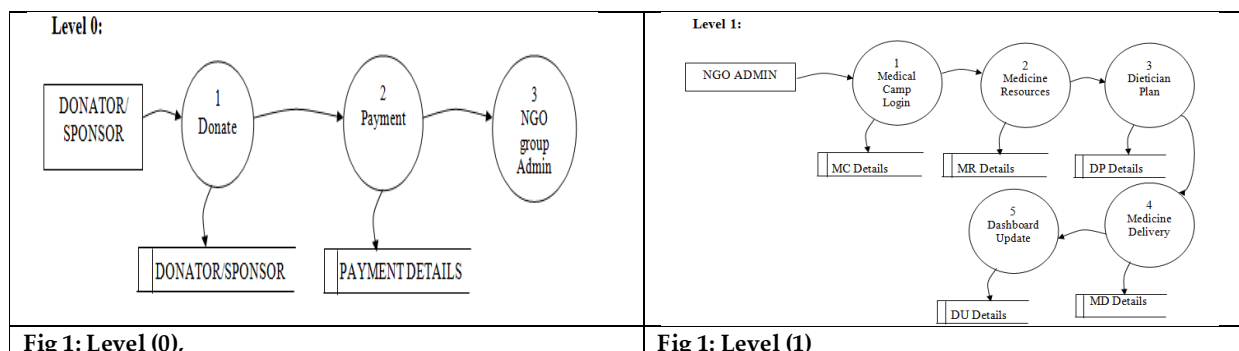
E-Medicine donation practices that have occurred previously during natural disasters and other emergency situations expose both the positive and detrimental effects donations can have on a recipient country. By including a broad definition of appropriate recipients, such as governments, NGOs and health facilities[4], the benefits of medicine donations could be enhanced. This is especially relevant in scenarios where a government is unstable or there is a severe lack of capacity and NGOs and/or health facilities are in a position to take on the role of managing a donation. Past experiences show that guidelines for the donation of medicines are both necessary and such adjustments could improve guideline adoptability by all involved parties and optimize donation procedures with the potential to improve outcomes in the future[2].

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Sivakumar

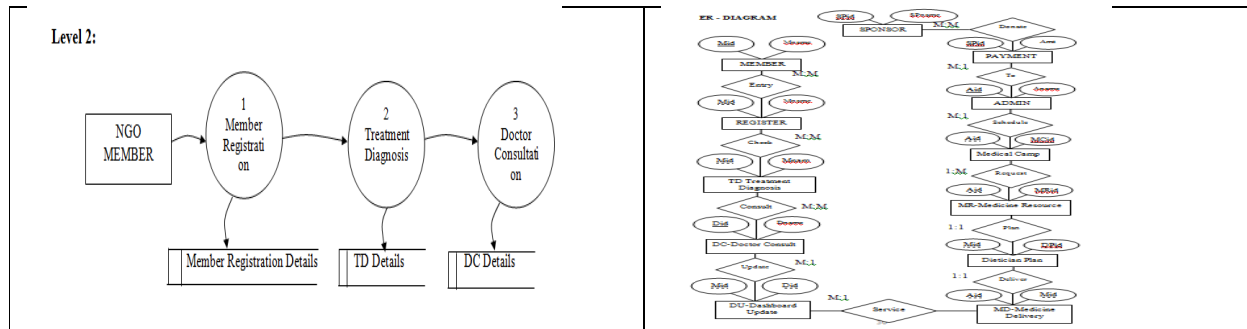


Fig 1: Level (2) is Data Flow Diagram

Fig 2: ER-Diagram



Fig 3: Home page

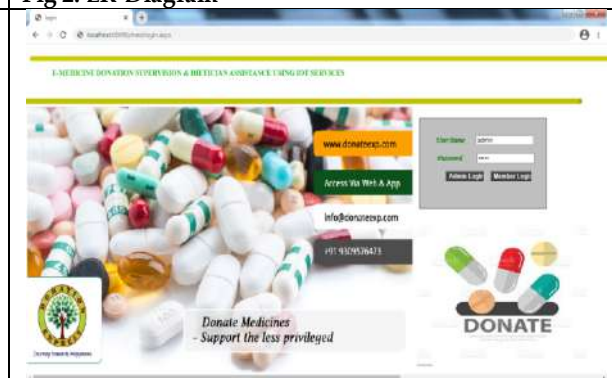


Fig 4: Admin Login Page



Fig 5: Member Login Page

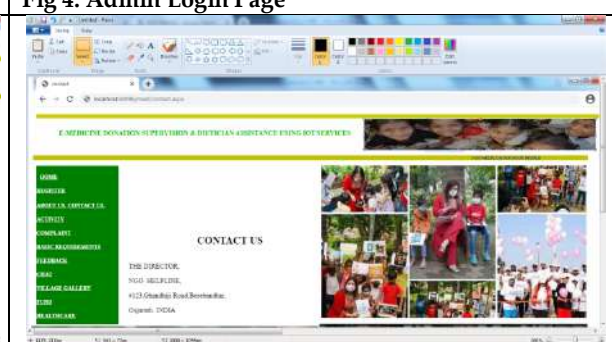


Fig 6: Contact Us Page



Fig 7: Health Care page



Fig 8: Activity Page





## An Insight into the Theoretical Perspectives of the Portrayal of Women in the films of Mahboob Khan" with reference to the Bollywood films "Aurat" and "Mother India

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### ABSTRACT

This research paper provides an insight into the theoretical perspectives of the portrayal of women in Bollywood films, with a particular focus on the works of director Mahboob Khan, specifically his films *Aurat* (1940) and *Mother India* (1957). The study examines the various ways in which these films represent women and their roles in Indian society, both historically and culturally. By employing feminist, cultural, and cinematic theories, the study investigates the evolution of female characters in Bollywood, highlighting the socio-cultural contexts that influenced their depiction. Through a critical analysis of the narratives, characters, and visual representation in these films, the paper explores the various ways in which they reinforce or subvert dominant patriarchal norms and ideologies. The research compares the roles of women in *Aurat*, a film from the 1940s, with those in *Mother India*, a celebrated work from the 1950s, to discern changing trends and ideologies over the decades. The paper argues that while *Aurat* and *Mother India* reinforce some traditional gender roles, they also challenge others, particularly in their portrayal of strong female protagonists who defy societal norms and expectations. The study also examines the ways in which the films reflect and engage with broader social





Mohammad Ashraf Ali et al.,

and political issues, such as gender inequality, caste system, and nationalism. The study contributes to on-going conversations about gender, power, and identity in India and beyond, and provides insights into the ways in which cinema can shape and reflect societal attitudes towards women.

**Keywords:** Gender Representation, Feminist Theory, Mahboob Khan, Patriarchy, Stereotyping

## INTRODUCTION

Bollywood, the Indian film industry has a significant impact on society's perception of women. The portrayal of women in Indian cinema has been a topic of debate for years. Some argue that women are objectified and stereotyped, while others believe that Bollywood has made strides in portraying women as strong and independent characters. There are several theoretical perspectives that can be used to analyse the portrayal of women in Bollywood films. One such perspective is feminist theory, which focuses on the representation of women in media and the ways in which they are oppressed and marginalized. Feminist theory argues that women are often portrayed as passive, submissive, and dependent on men in Bollywood films. Women are often objectified and their bodies are used to sell films, while their roles in the story are limited. Historically, Bollywood has portrayed women as submissive and dependent on men. In the 1950s and 1960s, women were primarily depicted as homemakers and romantic interests for the male protagonist. However, in the 1970s and 1980s, the portrayal of women in Bollywood films started to change. Women characters were shown as strong and independent, fighting against societal norms and patriarchy. In recent years, Bollywood has been criticized for its portrayal of women as objects of desire. Women characters are often shown in revealing clothes, dancing to item songs, and being objectified for the male gaze. This has been a cause of concern for feminists and activists who believe that such representation reinforces gender stereotypes and promotes objectification of women. On the other hand, some scholars argue that Bollywood films have played a significant role in empowering women by portraying them as strong and independent.

Films like *Queen*, *English Vinglish*, and *Pink* have challenged societal norms and stereotypes by portraying women as individuals with agency and autonomy. However, it is important to note that the representation of women in Bollywood films is not a monolithic entity. There are films that portray women in a positive light, while others perpetuate gender stereotypes. It is also essential to understand that Bollywood films are not created in a vacuum but are reflective of society's attitudes and beliefs about women. There are several theoretical perspectives that can be used to analyze the portrayal of women in Bollywood films. One such perspective is feminist theory, which focuses on the representation of women in media and the ways in which they are oppressed and marginalized. Feminist theory argues that women are often portrayed as passive, submissive, and dependent on men in Bollywood films. Women are often objectified and their bodies are used to sell films, while their roles in the story are limited. The portrayal of women in Bollywood films has evolved over the years, but there is still room for improvement. Bollywood has the power to influence societal attitudes towards women, and it is crucial that filmmakers take responsibility for the representation of women in their films. By portraying women as individuals with agency and autonomy, Bollywood can play an important role in promoting gender equality and empowering women. In order to understand the portrayal of women in Bollywood, we may take help of the following theories:

1. Feminist Film Theory
2. Patriarchy and Hegemonic Masculinity
3. Representation Theory
4. Intersectionality and Women's Identity
5. Role of Auteur Directors

### Feminist Film Theory

Feminist film theory is a critical and academic approach to studying and analyzing films from a feminist perspective. It emerged in the late 1960s and has since evolved into a diverse and multidisciplinary field. This theory is rooted in







**Mohammad Ashraf Ali et al.,**

the broader feminist movement, which seeks to understand and address the ways in which gender inequality and patriarchy influence various aspects of society, including the world of cinema. Feminist film theory has been instrumental in challenging the status quo in the film industry and promoting a more inclusive and equitable representation of women in cinema. It has also contributed to the broader understanding of how media and culture intersect with issues of gender and identity. As the field continues to evolve, feminist film theory remains a dynamic and important part of film studies. Feminist Film Theory is a theoretical film criticism that arose from feminist politics and theories governed by the second wave feminism rooted from sociological theories concentrated on how the public scrutinizes how women deliver the attitudes, scenarios, and characters given to them to portray in a particular film in a television or cinema screens[2]. Feminist film studies, or gendered film studies, is intended to explore the ways in which women (and men) are represented by visual media, and film in particular. Feminists argue that media representations of gender perpetuate and reinforce the values of patriarchal society.[3] The subjectivity to women expressing herself didn't complete until the start of second feminist movement. Feminist Film Theory has evolved over the years, and scholars have elaborated their exertion on their dissertation and perusal on the discourses of the theory, taking into account even the domains of Television and Digital media where women workforce also thrives itself in interlacing success. Notable female filmmakers around the globe are working behind the camera who are excellent in the field of history-making film industry. Some of them include Kathryn Ann Bigelow, Sofia Coppola, Tanuja Chandra and many more[1].

#### **Feminist Film Theory in the Context of Mahboob Khan's Films Aurat And Mother India**

Feminist film theory can offer valuable insights when analyzing Mahboob Khan's films "Aurat" (1940) and "Mother India" (1957) in the context of Indian cinema. These films are significant in the history of Indian cinema and provide interesting case studies for applying feminist film theory.

#### **Representation of Women**

In both films, the representation of women is a central theme. "Aurat" focuses on the struggles of a mother, Radha, She is morally superior to the money lender- indeed to everybody else. The film Aurat was produced by National Studios. While "Mother India" portrays the life of Radha, a strong and resilient village woman. Feminist film theory would examine how these characters are portrayed and whether they challenge or reinforce traditional gender roles and stereotypes. For example, Radha in "Mother India" can be seen as a symbol of female strength and resilience in the face of adversity.

#### **Male Gaze**

Feminist film theory often critiques the concept of the "male gaze," which objectifies women for the pleasure of male viewers. In the context of Indian cinema, the question arises as to how these films were made for a predominantly male audience. Were elements of the male gaze evident in the portrayal of female characters? Did the films cater to certain male fantasies or expectations?

#### **Intersectionality**

Feminist film theory considers how gender intersects with other identity markers. In "Mother India," the character of Radha belongs to a rural, agrarian community, and her struggles are influenced by both her gender and her socio-economic status. Analyzing these intersections can provide a deeper understanding of the film's portrayal of women.

#### **Stereotyping and Subversion**

Feminist film theory looks at whether these films perpetuated stereotypes or subverted them. Did they challenge or reinforce traditional roles and expectations for women in Indian society at the time? For example, "Mother India" can be seen as subverting stereotypes by depicting a strong and independent female lead who makes significant sacrifices for her family, community and village honour when in the last scene, Radha tells her son Birju that the girl belongs to the whole community and she can even kill her own son to save the honour of community and her village.





Mohammad Ashraf Ali et al.,

### **Narrative Structure**

Feminist film theory would assess how the narrative structure of these films portrays women's agency and whether it reflects a patriarchal model or offers alternative storytelling approaches.

### **Audience Reception**

The theory also examines how audiences, particularly women, reacted to these films. Did they find empowerment in the characters' stories, or did they identify with the struggles depicted on screen?

It's worth noting that "Aurat" and "Mother India" were created in different eras and within different socio-cultural contexts. "Aurat" is a pre-independence film and may have been influenced by the prevailing societal norms of its time. In contrast, "Mother India" was made after India gained independence and represented a shift in the portrayal of women in Indian cinema<sup>5</sup>. Feminist film theory helps in contextualizing these changes and evaluating the impact of these films on the evolving role of women in Indian society. In summary, applying feminist film theory to Mahboob Khan's "Aurat" and "Mother India" allows for a nuanced analysis of how these films depict women, address gender issues, and engage with the evolving socio-cultural landscape of India. It helps uncover the ways in which these films either conform to or challenge traditional gender norms and narratives. Mahboob Khan's films *Aurat* and *Mother India* are considered as some of the most significant films in Indian cinema history. *Aurat* was made in the early 1940s and was remade in color as *Mother India* in 1956. Both films portray women as strong characters who are capable of making their own decisions. In *Aurat*, the protagonist Radha is a woman who is forced to make difficult choices to support her family. In *Mother India*, Nargis Dutt plays Radha, a woman who is forced to take on the responsibilities of her family after her husband abandons them. Both films are considered feminist because they challenge traditional gender roles and portray women as strong and independent[6]. Mahboob Khan's films *Aurat* and *Mother India* can be seen as feminist films because they challenge traditional gender roles and portray women as strong characters who are capable of making their own decisions.

### **Patriarchy**

Patriarchy has been an age-old, gender-binary, hierarchical social and cultural structure that exists as a set of rules, codes, and values specific to how men and women should behave in society. One does not need to research a lot to understand that patriarchy is grossly favouring men. However, although this structure essentially oppresses women for the advantage of men, Gilligan and Snider (2018) write that it can be damaging to both men and women. According to them, patriarchy is more of an internal root that dictates how we think, feel, judge, and perceive others and ourselves. The past decade has witnessed immense social growth with increasing acknowledgement of patriarchy's toxicity in the present-day sociological discourses. However, regardless of this gradual change, even as we have developed conscious attitudes of equality, there is a much larger context of what unconscious ideas of what women should be that hovers like a ghost, transforming mutuality between masculine and feminine subjectivities much harder than we think it should be. The difficulty in tackling patriarchy lies in its power being manifested so internally and deeply in the form of culturally approved ways of transgression against women. Society as a whole has been male-dominated for centuries dating back to several thousands of years ago. Patriarchy itself is believed to have developed its roots as far back as 4000 BC. A direct and natural result of the persistence of patriarchy is the social and political grasp of power by masculinity – in other words, the emergence and development of hegemonic masculinity.

### **Hegemony**

Antonio Gramsci articulated a fundamental principle of Marxist thought, known as Hegemony, which refers to the concept of domination. Gramsci developed this idea to explain why the powerless consent to being ruled by the powerful. He argued that the ruling class uses hegemonic ideas to gain control over the subjugated classes, manipulating language, culture, morality, and ideology. According to Gramsci, power stems from consent, obtained through subtle agreements. This collective influence of various notions shapes cultural hegemony.







Mohammad Ashraf Ali *et al.*,

### **Cultural Hegemony**

Antonio Gramsci formulated the concept of Cultural Hegemony by drawing on the ideas of Nietzsche, Machiavelli, and Karl Marx. He pointed that the ruling class spreads their ideologies through various institutions, shaping society's common understanding of reality. Manipulating cultural parameters through mass media allows those in power to effectively control populations and maintain the status quo.

### **Hegemonic Masculinity**

The concept of hegemonic masculinity, rooted in cultural hegemony theory, was introduced by Connell in the 1980s. It involves a dominant form of masculinity that is not oppressive but rather maintained through consent, legitimizing male dominance and the subordination of women. Hegemonic masculinity is the configuration of gender practice that embodies the currently accepted answer to the problem of the legitimacy of patriarchy – which guaranteed (or is taken to guarantee) the dominant position of men and the subordination of women.

### **Male Gaze**

The term "male gaze" was coined by Laura Mulvey, a theorist and filmmaker, and can be traced back to the origins of cinema. This concept revolves around the hyper sexualization and objectification of women in film. Mulvey explains that women have been perceived as objects of visual pleasure and sexual gratification for men in cinema for a long time. As Berger accurately describes it, "Men act, women appear, Men look at women; women watch themselves being looked at." This objectification is not always obvious, but is often presented as something desired by women as a form of reciprocation of sexual interest. The male gaze is a concept that highlights how patriarchal society has shaped film-making. Throughout history, men have been the primary focus of movies, with their experiences and emotions taking centre stage. This is reflected in every aspect of film production, from the writing of the script to the final edit. As a result, the stories that are told are influenced by a male worldview, including their views on women and their issues. Women have often been objectified and fetishized in film, which can be attributed to men's sexuality playing a significant role in the execution of their cinematic vision. Cinema continues to function under the dominant ideology that women are a secondary, oppressed gender, and exist solely for the visual pleasure of men.

### **Representation Theory**

Media studies often consider representation as a fundamental aspect, examining how media portrays reality, including social groups, events, and places. The accuracy of these representations can vary, but Stuart Hall challenged the idea that the original subject has a single fixed meaning that can be measured for accuracy. Hall argued that representation is not an afterthought, but rather a constitutive element. Media representations do not simply reflect pre-existing meanings, but instead create meaning for events that occur in reality. Hall also emphasized the powerful influence of mass media in the digital age, noting that much of society's understanding of the world is shaped by media producers who hold power and try to impose specific meanings on real-world phenomena. The wealthy white straight men, as such the representations we see in the media tend to reflect their ideology on politics, on social issues, gender, race etc. The media often reflects the political and social ideologies of those in power, resulting in limited representations of various groups such as race and gender.

This repetition of certain representations can lead to the creation of stereotypes. When these stereotypes are consistently portrayed over time, it can narrow society's perception of the world and lead to the normalization of these limited representations. The representation becomes naturalized and we stop questioning it. To combat this, audiences should question the purpose and agenda behind media texts and the creators behind them. By doing so, we can avoid the pigeonholing of social groups and the creation of a sense of otherness or alienation within society. The words sex and gender are often mistakenly used interchangeably. Sex refers to a person's biological identity, while gender is a social construct that defines a person's social identity. Sex determines if someone is male or female based on their sexual identity, while gender determines if someone is a man or woman based on their gender identity. The criteria for classifying someone's sex can be based on their genitalia at birth or chromosomal typing before birth. On the other hand, gender is shaped by societal norms and expectations regarding appropriate attitudes





Mohammad Ashraf Ali et al.,

and activities based on a person's sex category. Gender activities reinforce claims to membership in a particular sex category.

### Indian Cinema and Female Representation

Movies depict societal stereotypes, particularly regarding gender. The combination of storytelling and visual spectacle in cinema reinforces patriarchal ideologies. This is evident in both Hollywood and Bollywood films, where the female body is often objectified for male viewers' pleasure. Movies often promote masculinity, creating a fascination with male heroes while undermining female characters as mere accessories. Gender and racial stereotypes in film are still present but are gradually improving. The cinema's perspective is usually constructed from the idealized male viewpoint, which seeks power and control over what is shown. Indian films explore societal and cultural structures, sometimes challenging norms but often upholding them. Cinema holds meaning related to the subordinate position of the urban poor, with issues of class and power being crucial in understanding the audience's relationship with the medium. While Indian films touch on gender issues, their efforts and significance in addressing them are insufficient. Indian society worships goddesses but fails to celebrate womanhood, leading to contradictory treatment of women. Women have been socialized to internalize patriarchal ideology, contributing to their own subordination. Women in colonial and post-Partition India faced different feminist struggles compared to those in the West. After India gained independence, women's role in the public sphere diminished as men took charge, expecting them to fulfill traditional roles. In contrast, women in the US and UK had to fight for their right to vote, while Indian women gained this right naturally with the introduction of the Constitution in 1950. Therefore, their struggles were distinct. After the struggle for freedom, women's social and political roles were overshadowed by men. Despite India being referred to as 'Mother India', the distinction between real and imagined women is significant. The societal status of women, the bias in the community constructed on a patriarchal framework, establishes the structure of women portrayal in Indian movies. As argued by Shakuntala Rao, "the differentiation between "authentic" and "imagined" women is - one enduring the agony of patriarchy and the other idolized for being the vessel that tragically and silently endures pain."

"Women were perceived and comprehended solely through the lens of males." The narratives depicted on the screen are about men, their conflicts, dreams, aspirations, tragedies, revenge, desires, and heroism. Women exist solely in relation to men, as their mothers, wives, and particularly their lovers. It is difficult to discover even one story revolving around an unattached woman, and naturally, there is the adoration of youth and 'beauty.' Women are shown as bearers of tradition and rituals. Their identities are often intertwined with the natural and cultural identity of the society. The woman's body carries cultural signs; symbols of marriage like the mangalsutra and sindoor are idealized. The traditional/modern dichotomy concerning women's issues resides within another dichotomy of body/soul, outer/inner. Indian cinema strongly emphasizes the family system, which is an extension of society and its characteristics in general. "Gender politics, the portrayal of masculinity and femininity, and the interaction between them in heterosexual romance and family are all vital aspects of Hindi popular cinema and its depiction of the nation's social history and cultural politics." The female characters in Indian cinema assume the roles assigned to male characters; "their relation to the hero - his lover, mother, or the "other" woman - upholds the male protagonist's centrality."

### Representation and Stereotypes in Hindi Cinema In The Context of Mahboob Khan's Aurat And Mother India

Representation and stereotypes in Hindi cinema (often referred to as Bollywood) have been subjects of significant discussion and analysis. Hindi cinema has played a crucial role in shaping popular culture in India and beyond, and it has both challenged and perpetuated various representations and stereotypes, particularly in relation to gender, class, and more. Representation and stereotypes in Hindi cinema, as seen in Mahboob Khan's films "Aurat" (1940) and "Mother India" (1957), provide a context for exploring how these issues were portrayed during their respective eras:





Mohammad Ashraf Ali et al.,

### Gender Representation

**Stereotypes in "Aurat":** In "Aurat," the female characters, including Radha, the protagonist, were often depicted within traditional gender roles. Radha's identity is largely tied to her role as a mother and caregiver. The film reinforces the stereotype of the self-sacrificing, virtuous woman, who endures suffering and hardship for the sake of her family, village and community.

**"Mother India" and Female Empowerment:** "Mother India" represents a shift in gender representation compared to "Aurat." While Radha, the lead character, also embodies traditional virtues, she exhibits greater agency and resilience. Radha defies stereotypes by challenging patriarchal norms, even when it involves difficult decisions like killing her wayward son. The film can be seen as a more empowering portrayal of a female character, subverting traditional gender roles to some extent.

### Class Representation

**Stereotypes in "Mother India":** "Mother India" addresses issues related to poverty and class but can sometimes fall into stereotypes. The character of Sukhilala, the wealthy moneylender, is portrayed as corrupt and exploitative, while Radha and her family represent virtuous rural poverty. This dichotomy simplifies class dynamics and portrays them in a stereotypical manner.

### Rural Identity

**"Mother India" and Rural Life:** Both films emphasize the rural setting as an essential aspect of the characters' identities. "Mother India" portrays the struggles, values, and culture of rural life. It can be seen as both a representation of and a stereotype of rural life in India. The film, to some extent, reinforces the notion that the rural setting represents virtue and morality.

### Motherhood

**Stereotypes and Empowerment in "Mother India" and "Aurat":** Motherhood plays a central role in both films. In "Aurat," Radha's motherhood is depicted as a selfless and sacrificial role, conforming to stereotypes of the nurturing mother. In "Mother India," Radha's motherhood is portrayed as both nurturing and fiercely protective, subverting stereotypes by showing a mother who can be strong and assertive.

### Community and Social Norms

**Community Norms in "Mother India" and "Aurat":** Both films underscore the importance of community and social norms in shaping characters' identities. Radha's identity in "Mother India" is closely tied to her role as a respected member of her village, and the film reflects the community's values and norms. Overall, while Mahboob Khan's films "Aurat" and "Mother India" do incorporate elements of gender, class, and rural identity representation, they also contain elements that challenge traditional stereotypes. "Mother India" in particular offers a more empowered and nuanced portrayal of women, suggesting that even within the context of their times, efforts were made to depict women in complex and multifaceted roles. These films provide insights into the evolving representations and challenges of identity in Hindi cinema, reflecting the socio-cultural dynamics of their respective eras. The Indian film industry, popularly known as Bollywood, has been a significant source of entertainment for the masses since its inception in the 1930s. However, the industry has been criticized for its portrayal of women.

Women are often portrayed in a stereotypical manner, with their roles reduced to misogynistic ideals. The lack of equality both on and off-screen has raised questions on gender stereotyping, the quality of media being viewed by the public, and the misinterpretation of a balanced society.[7]Mahboob Khan's films *Aurat* and *Mother India* are considered as some of the most significant films in Indian cinema history. *Aurat* was made in the early 1940s and was remade in color as *Mother India* in 1956. Both films portray women as strong characters who are capable of making their own decisions. In *Aurat*, the protagonist Radha is a woman who is forced to make difficult choices to support her family. In *Mother India*, Nargis Dutt plays Radha, a woman who is forced to take on the responsibilities of her family after her husband abandons them. Both films are considered feminist because they challenge traditional



**Mohammad Ashraf Ali et al.,**

gender roles and portray women as strong and independent.[8] In conclusion, Bollywood has been criticized for its portrayal of women and minorities. Women are often portrayed in a stereotypical manner, with their roles reduced to misogynistic ideals.<sup>9</sup> However, Mahboob Khan's films *Aurat* and *Mother India* can be seen as feminist films because they challenge traditional gender roles and portray women as strong characters who are capable of making their own decisions.

**Intersectionality and Women's Identity in The Context Of Mahboob Kan's Films *Aurat* And *Mother India***

Intersectionality is a term that describes how different factors of discrimination can affect someone's life. It is a theory that shows how a feminism that focuses only on women – without considering their class, ethnicity, sexuality, ability and more – favours the needs of those who are white, middle-class, heterosexual and able bodied.[10] Intersectionality recognizes that women's identity is shaped by multiple factors such as gender, race, ethnicity, class, sexuality, ability and more. Mahboob Khan's films *Aurat* and *Mother India* can be seen as feminist films because they challenge traditional gender roles and portray women as strong characters who are capable of making their own decisions.[11] Examining intersectionality and women's identity in the context of Mahboob Khan's films "*Aurat*" (1940) and "*Mother India*" (1957) within the Indian cinematic landscape provides a unique perspective on the representation of women. These films depict the complexities of women's experiences, intersecting with various identity markers such as class, rural life, and traditional values

**Class and Economic Status** Both films center around female protagonists who face economic hardship. In "*Aurat*," the protagonist Radha is a poor woman struggling to provide for her children. In "*Mother India*," Radha faces similar economic challenges as a rural, impoverished woman whose husband has abandoned her. Intersectionality within these films highlights how gender and class intersect, revealing the unique hardships faced by impoverished women.

**Rural vs. Urban Identity** "*Mother India*" underscores the intersection of gender and rural life. The film's portrayal of rural women captures the specific challenges and roles they faced in agrarian societies. Radha's identity is deeply entwined with her role as a rural mother, emphasizing how women's identities can be shaped by their geographical and cultural contexts.

**Motherhood** Both films delve into the intersection of women's identities and their roles as mothers. Radha in "*Mother India*" is often identified by her selfless devotion to her children, reflecting how motherhood is a fundamental aspect of her identity.

**Traditional Values and Patriarchy** The films also depict the intersection of gender identity with traditional values and patriarchy. They reveal the challenges faced by women who defy traditional norms, like Radha in "*Mother India*," who breaks away from patriarchal constraints to protect her family. This intersection highlights the tension between conforming to societal norms and asserting one's individual identity.

**Community and Social Norms** Both films portray the influence of community and social norms on women's identity. The characters are embedded within their communities, and these communities shape their identities. Radha's identity in "*Mother India*" is closely tied to her role as a respected member of her village. By applying an intersectional lens to these films, we can appreciate how the identities of the female characters are multifaceted, shaped not only by their gender but also by class, rural life, marital status, motherhood, and traditional values. These intersections serve to create rich and complex character portrayals and narratives. Furthermore, the films reflect the broader socio-cultural context of their times, addressing issues that were relevant to Indian women during those eras. In summary, "*Aurat*" and "*Mother India*" offer valuable insights into the intersectionality of women's identities, illustrating how various aspects of identity, such as class, rural life, and traditional values, intersect with gender to shape the experiences and challenges faced by the female characters. These films serve as important cultural artifacts for exploring the complex intersections of women's identities in the Indian cinematic context.





Mohammad Ashraf Ali et al.,

### Role of Auteur Directors In Hindi Cinema

Auteur theory is a film criticism concept that emphasizes the director's creative vision as the primary author of a film. In Hindi cinema, auteur directors are those who have a distinct style and vision that is evident in their films. These directors are known for their unique approach to filmmaking, which often includes unconventional storytelling techniques, innovative camera work, and a focus on character development.[12] Some of the most notable auteur directors in Hindi cinema include Satyajit Ray, who is known for his realistic portrayal of Indian life and culture. Another notable director is Guru Dutt, who is known for his innovative use of music and dance in his films. Other notable auteur directors include Shyam Benegal, Raj Kapoor, Bimal Roy, and Yash Chopra.[13] In conclusion, auteur directors in Hindi cinema are known for their unique approach to filmmaking and their distinct style and vision. These directors have made significant contributions to Indian cinema and have helped shape the industry into what it is today. The role of auteur directors in Hindi cinema, often referred to as Bollywood, has been significant in shaping the industry and influencing the art of filmmaking. Auteur directors are those whose artistic vision and distinctive style are readily recognizable throughout their body of work. In Hindi cinema, auteur directors have played a crucial role in both commercial and artistic aspects of filmmaking. Here's an overview of their role and impact

### Role of Auteur Directors in Hindi Cinema in The Context Of Mahboob Khan's Aurat And Mother India

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Mahboob Khan, the director of "Aurat" (1940) and "Mother India" (1957), can be considered an influential figure in Hindi cinema who exhibited characteristics of an auteur director. Here's how his role aligns with the concept of an auteur director in the context of these two films:

### Distinctive Style and Vision

Mahboob Khan's films often exhibited a distinctive style, characterized by a focus on social issues, rural life, and strong female protagonists. Both "Aurat" and "Mother India" reflect his vision of telling stories that highlight the resilience and strength of women in challenging circumstances.

### Storytelling and Themes

Mahboob Khan's films consistently explored themes related to women's struggles, societal norms, and family dynamics. In "Aurat," the theme of maternal sacrifice and redemption is prevalent, while "Mother India" delves into issues of rural life, poverty, and the indomitable spirit of a mother. These recurring themes are indicative of an auteur's personal narrative interests.

### Consistency in Quality

Mahboob Khan maintained a certain level of consistency in the quality of his work, particularly in addressing social issues and crafting compelling narratives. His films were often well-received by both audiences and critics, showcasing a commitment to excellence.







Mohammad Ashraf Ali et al.,

### Artistic Control

Mahboob Khan was known for his artistic control over his projects. He was deeply involved in the scripting, direction, and overall execution of his films. This level of involvement is a characteristic of auteur directors who maintain creative control.

### Cinematic Innovation

While both "Aurat" and "Mother India" may not have been groundbreaking in terms of cinematic techniques, they did feature certain innovative elements within the constraints of their times. These innovations, such as storytelling methods and cinematography, contributed to the evolution of Hindi cinema.

### Impact on Film Industry

Mahboob Khan's work and thematic choices influenced subsequent generations of filmmakers in Bollywood. His films addressed important social issues and showcased the potential of Indian cinema as a medium for both entertainment and societal reflection.

### Cultural and Social Commentary

Both "Aurat" and "Mother India" can be seen as a form of cultural and social commentary. Mahboob Khan used his films to comment on issues of poverty, gender roles, and the indomitable human spirit. His work was instrumental in sparking conversations about these topics in Indian society. While Mahboob Khan's auteur status may not be as universally recognized as some other directors, his distinctive style, consistent themes, and significant influence on the industry align with the attributes of an auteur director. His films, particularly "Mother India," are celebrated for their lasting impact on Hindi cinema, emphasizing the potential of filmmakers to be influential voices in the industry and society at large. In conclusion, Mahboob Khan's films *Aurat* and *Mother India* can be seen as examples of auteur cinema because they have a distinct style and vision that is evident in their filmmaking techniques. These films challenge traditional gender roles and portray women as strong characters who are capable of making their own decisions.

## CONCLUSION

In conclusion, this research paper has presents a broad scrutiny of the theoretical perspectives surrounding the depiction of women in Bollywood cinema, with a meticulous spotlight on the works of director Mahboob Khan, particularly his films *Aurat* and *Mother India*. By utilizing feminist, cultural and cinematic theories, this study has explored the progress of feminine characters in Hindi cinema, inspecting the socio-cultural background that influences their portrayal. Through a serious examination of the description, personality and visual illustration in *Aurat* and *Mother India*, it has been divulged that these films both strengthen and confront conventional gender roles and patriarchal norms. While they encourage certain societal prospects, they also present strong womanly characters who disregard these norms, offering a nuanced depiction of women in Indian society. In addition, this research paper has investigated how these films employ with broader social and political issues such as sexual discrimination, the caste structure and patriotism. By doing so, they not only amuse but also provide as a expression of the society in which they were built. Finally, this research contributes to continuing discussion adjoining gender, power and individuality not only in India but also outside its borders. It emphasizes the approach in which films can figure and reproduce public outlook towards women, and the power of films to challenge and renovate customary gender roles. On the whole, this research paper provides valuable insights into the representation of women in Hindi Films, throwing light on the intricacies and tone of their depiction. By scrutinizing the accomplishments of Mahboob Khan, mainly *Aurat* and *Mother India*, this study puts forward a deeper perceptive of the growing role of women in Indian society and the traditions in which Bollywood Films can both strengthen and confront public customs.





Mohammad Ashraf Ali et al.,

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# On Some Transformations and Summations of Basic Hypergeometric Series-I

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## ABSTRACT

The object of this paper is to establish some transformation formulae for basic hyper geometric series by making use of some known results.

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**Keywords:** Basic hyper geometric series, Gauss’s summation formula.

## INTRODUCTION

The generalized basic hyper geometric series is defined by

$${}_r\phi_s \left[ \begin{matrix} a_1, a_2, \dots, a_r; q, Z \\ b_1, b_2, \dots, b_s \end{matrix} \right] = \sum_{n=0}^{\infty} \frac{(a_1, q)_n (a_2, q)_n \dots (a_r, q)_n}{(b_1, q)_n (b_2, q)_n \dots (b_s, q)_n} [(-1)^n q^{n(n-1)/2}]^{1+s-r} z^n \quad (1)$$

where  $r$  and  $s$  are positive integers,  $q \neq 0$  when  $r > s + 1$ , the numerator parameters  $a_1, \dots, a_r$ , and the denominator parameters  $b_1, \dots, b_s$  being complex quantities provided that  $b_j \neq q^{-m}; m = 0; 1; \dots; j = 1; 2; \dots; s$

For real or complex  $a, q < 1$ , the  $q$ -shifted factorial is defined by

$$(a, q)_n = \begin{cases} 1 & \text{if } n = 0; \\ (1-a)(1-aq)(1-aq^2) \dots (1-aq^{n-1}) & \text{if } n \in N. \end{cases} \quad (2)$$

In 1971 Verma established the following  $q$ -series identity

$$\sum_{n=0}^{\infty} \frac{(-z)^n q^{n(n-1)/2}}{(q, \gamma q^n; q)_n} \sum_{k=0}^{\infty} \frac{(\alpha, \beta; q)_{n+k}}{(q, \gamma q^{2n+1}; q)_k} B_{n+k} z^k \sum_{j=0}^{\infty} \frac{(q^{-n}, \gamma q^n; q)_j}{(q, \alpha, \beta; q)_j} A_j (wq)^j = \sum_{n=0}^{\infty} A_n B_n \frac{(zw)^n}{(q; q)_n} \quad (3)$$





**Jayprakash Yadav and NidhiSahni**

The multi-basic hypergeometric series with bases  $q_1, q_2, \dots, q_m$  is defined as

$$\phi \left[ \begin{matrix} a_1, a_2, \dots, a_r; c_{1,1}, \dots, c_{1,r_1}; \dots; c_{m,1}, \dots, c_{m,r_m}; q; q_1, q_2, \dots, q_m; z \\ b_1, b_2, \dots, b_s; d_{1,1}, \dots, d_{1,s_1}; \dots; d_{m,1}, \dots, d_{m,s_m} \end{matrix} \right] = \sum_{n=0}^{\infty} \frac{(a_1, q)_n (a_2, q)_n \dots (a_r, q)_n z^n}{(b_1, q)_n (b_2, q)_n \dots (b_s, q)_n} \prod_{j=1}^m \frac{(c_{j,1}, c_{j,2}, \dots, c_{j,r_j}; q_j)_j}{(d_{j,1}, d_{j,2}, \dots, d_{j,s_j}; q_j)_j} \tag{4}$$

where  $(a_1, a_2, \dots, a_r; q)_n = (a_1; q)_n (a_2; q)_n \dots (a_r; q)_n$ .

We shall use the following summation formulae due to Verma and Jain [8]

$${}_4\phi_3 \left[ \begin{matrix} b^2 x^4 q^{2+2n}, x^2, x^2 q, q^{-2n}, q^2; q^2 \\ bx^2 q, bx^2 q^2, x^4 q^2 \end{matrix} \right] = \frac{x^{2n} (-q, bq; q)_n}{(-x^2 q, bx^2 q; q)_n} \tag{5}$$

$${}_5\phi_4 \left[ \begin{matrix} a, aq, aq^2, a^3 q^{3+3n}, q^{-3n}, q^3; q^3 \\ aq\sqrt{aq}, -aq\sqrt{aq}, a^{3/2} q^3, -a^{3/2} q^3 \end{matrix} \right] = \frac{a^n (q^3, q^3)_n (aq; q)_n}{(a^3 q^3; q^3)_n (q; q)_n} \tag{6}$$

$${}_6\phi_5 \left[ \begin{matrix} a^{1/3}, a^{1/3} q, a^{1/3} q^2, q\sqrt{a}, aq^{n+1}, q^{-n}, q; q \\ \sqrt{a}, -\sqrt{a}, \sqrt{aq}, -\sqrt{aq}, q^2\sqrt{a} \end{matrix} \right] = \frac{a^{(n-m)/2} (q, \sqrt{a}; q)_n (aq^3, q^6\sqrt{a}; q^3)_m}{(aq, q^2\sqrt{a}; q^3)_n (q^3, \sqrt{a}; q^3)_m} \tag{7}$$

### RESEARCH METHODOLOGY

Published research Papers and reference books in the field of Basic Hyper geometric Series.

#### Main Results

$$\phi \left[ \begin{matrix} \alpha, -\alpha, \beta, -\beta, bx^2 q, bq : : bx^2 q^2, bx^2 q^3, bx^2 q^4, bx^2 q^5, -bx^2 q^2, -bx^2 q^3, -bx^2 q^4, -bx^2 q^5; q, q^2, q^4; \frac{b^2 x^4 q^4}{\alpha^2 \beta^2} \\ x^2 q, \frac{bx^2 q^3}{\alpha}, -\frac{bx^2 q^3}{\alpha}, \frac{bx^2 q^3}{\beta}, -\frac{bx^2 q^3}{\beta} : : bx^2 q^3, bx^2 q, -bx^2 q^2 : : q^2 \end{matrix} \right] = \prod \left[ \begin{matrix} b^2 x^4 q^4, \frac{b^2 x^4 q^4}{\alpha^2 \beta^2}, q^2 \\ \frac{b^2 x^4 q^4}{\alpha^2}, \frac{b^2 x^4 q^4}{\beta^2} \end{matrix} \right] {}_4\phi_3 \left[ \begin{matrix} \alpha^2, \beta^2, x^2, x^2 q; q^2; \frac{b^2 x^4 q^4}{\alpha^2 \beta^2} \\ bx^2 q, bx^2 q^2, x^4 q^2 \end{matrix} \right] \tag{8}$$

$$\phi \left[ \begin{matrix} aq; \alpha^3, \beta^3 : : a^3 q^6, a^3 q^9, a^3 q^{12}, a^3 q^{15}, a^3 q^{18}, a^3 q^{21}; q, q^3, q^6, q^{18}; \frac{a^4 q^6}{\alpha^3 \beta^3} \\ \frac{a^3 q^6}{\alpha^3}, \frac{a^3 q^6}{\beta^3} : : a^3 q^3, a^3 q^6 : : q^3 \end{matrix} \right] = \prod \left[ \begin{matrix} a^3 q^6, \frac{a^3 q^6}{\alpha^2 \beta^2}, q^3 \\ \frac{a^3 q^6}{\alpha^2}, \frac{a^3 q^6}{\beta^2} \end{matrix} \right] {}_5\phi_4 \left[ \begin{matrix} \alpha^3, \beta^3, a, aq, aq^2; q^3; \frac{a^3 q^6}{\alpha^3 \beta^3} \\ (aq)^{3/2}, -(aq)^{3/2}, a^{3/2} q^3, -a^{3/2} q^3 \end{matrix} \right] \tag{9}$$

$$\sum_{n=0}^{\infty} \frac{(\alpha, \beta, q^{3/2}\sqrt{a}, -q^{3/2}\sqrt{a}; q)_n (a^{1/3} q, a^{1/3} q w^2; q)_m (-z)^n (\sqrt{a})^{n-m} q^{n(n-1)/2}}{(\sqrt{aq}, -\sqrt{aq}, \frac{aq^2}{\alpha}, \frac{aq^2}{\beta}; q)_n (q, qw, qw^2; q)_m} = \prod \left[ \begin{matrix} aq^2, \frac{aq^2}{\alpha\beta}, q \\ \frac{aq^2}{\alpha}, \frac{aq^2}{\beta} \end{matrix} \right] {}_5\phi_4 \left[ \begin{matrix} \alpha, \beta, a^{1/3}, a^{1/3} w, a^{1/3} w^2; q; \frac{aq^2}{\alpha\beta} \\ q\sqrt{a}, -q\sqrt{a}, \sqrt{aq}, -\sqrt{aq} \end{matrix} \right] \tag{10}$$





**Jayprakash Yadav and NidhiSahni**

$$\sum_{n=0}^{\infty} \frac{(\alpha, \beta, q^{3/2}\sqrt{a}, -q^{3/2}\sqrt{a}; q)_n (a^{1/3}q, a^{1/3}qw, a^{1/3}qw^2, a^{1/6}q^2w, a^{1/6}q^2w^2; q)_m}{(\sqrt{aq}, -\sqrt{aq}, \frac{aq^2}{\alpha}, \frac{aq^2}{\beta}, q^2\sqrt{a}; q)_n (q, qw, qw^2, a^{1/6}q^{2/3}, a^{1/6}q^{2/3}w, a^{1/6}q^{2/3}w^2; q)_m} (-z)^n (\sqrt{a})^{n-m} q^{n(n-1)/2}$$

$$= \prod \left[ \frac{aq^2, \frac{aq^2}{\alpha\beta}, q}{\frac{aq^2}{\alpha}, \frac{aq^2}{\beta}} \right]_{6\phi_3} \left[ \begin{matrix} \alpha, \beta, a^{1/3}, a^{1/3}w, a^{1/3}w^2, q\sqrt{a}; q; \frac{aq^2}{\alpha\beta} \\ q^2\sqrt{a}, \sqrt{a}, -\sqrt{a}, \sqrt{aq}, -\sqrt{aq} \end{matrix} \right] \tag{11}$$

**Proof of (8)**

Choosing  $A_j = \frac{(\alpha^2, \beta^2, x^2, -x^2q; q^2)_j}{(bx^2q, bx^2q^2, x^4q^2; q)_j}, B_n = 1, w = 1, z = \frac{b^2x^4q^4}{\alpha\beta}$  in equation (3) and making use of equation (5) and Gauss’s Summation Formula [Slater [7]; App.iv (iv.2)] in order to sum the inner series on the left-hand side of (3), we get (8).

**Proof of (9)**

Choosing  $A_j = \frac{(a, aq, aq^2, \alpha^3, \beta^3; q)_j}{((aq)^{3/2}, -(aq)^{3/2}, a^{3/2}q^3, -a^{3/2}q^3; q)_j}, B_n = 1, w = 1, z = \frac{a^3q^6}{\alpha^3\beta^3}$  and  $\gamma = b^2x^4q^2$  in equation (3) and making use of equation (5) and Gauss’s Summation Formula [Slater [7]; App.iv (iv.2)] in order to sum the inner series on the left hand side of (3), we get (8).

**Proof of (10)**

Choosing  $A_j = \frac{(\alpha, \beta, a^{1/3}, a^{1/3}w, a^{1/3}w^2; q)_j}{(q\sqrt{a}, -\sqrt{a}, \sqrt{aq}, -\sqrt{aq}; q)_j}, B_n = 1, w = 1, z = \frac{aq^2}{\alpha\beta}$  and  $\gamma = aq$  in equation (3) and making use of equation (5) and Gauss’s Summation Formula [Slater [7]; App.iv (iv.2)] in order to sum the inner series on the left hand side of (3), we get (8).

**Proof of (11)**

Choosing  $A_j = \frac{(\alpha, \beta, a^{1/3}, a^{1/3}w, a^{1/3}w^2, q\sqrt{a}; q)_j}{(q^2\sqrt{a}, \sqrt{a}, -\sqrt{a}, \sqrt{aq}, -\sqrt{aq}; q)_j}, B_n = 1, w = 1, z = \frac{aq^2}{\alpha\beta}$  and  $\gamma = aq$  in equation (3) and making use of equation (5) and Gauss’s Summation Formula [Slater [7]; App.iv (iv.2)] in order to sum the inner series on the left hand side of (3), we get (8).

**CONCLUSIONS AND SUGGESTIONS**

In the present research paper, several transformation formulas have been established that may be helpful to the researchers in the field of Basic hyper geometric series. Some special cases may be derived by suitably choosing the arguments.

**ACKNOWLEDGE**

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**Jayprakash Yadav and NidhiSahni**

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## Revolutionizing Education: Unraveling the Transformative Effects of Covid-19 Pandemic on Teaching and Learning

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### ABSTRACT

In this paper, we examine the challenges teachers and students face in online teaching during the Covid-19 pandemic, as well as how this pandemic has impacted the teaching methods of teachers and the lives of students. Teachers and students participated in the study, which yielded valuable information for the researcher. To select these samples, we used the Random Samples Method. Due to the Covid-19 pandemic, a large number of teachers are conducting their first online classes. They're open to experimenting with new teaching methods and technologies. A survey of online teachers found that Zoom, Google Meet, and Google Classroom were the most commonly used tools. While teaching online, respondents encountered a wide range of difficulties, but reaching students in remote areas and teaching math were the most difficult. Despite the difficulties, many respondents said they were satisfied with online teaching and were willing to face additional difficulties in order to make learning more accessible to students. There are many issues students face during online sessions, including a lack of focus, difficulty comprehending what the teacher is saying, and more.

**Keywords:** Covid-19 Pandemic, Teacher, Students, Challenges, Online Teaching



**Khursheed Alam et al.,**

## INTRODUCTION

Lifelong learning is an individual's lifelong endeavor. Teachers and students both benefit greatly from the importance of education. Learning is important because it enables an individual to acquire the necessary skills and knowledge to achieve his or her desired goals in life through learning and education. Indian educational institutions (colleges and universities) rely solely on old-fashioned teaching methods, such as face-to-face classes where students sit in rows facing one another. Even though many academic institutions have begun using blended learning, many of them are still using outdated methods by Blissitt (2016). World markets were rattled by the sudden emergence of a deadly disease known as Covid-19, which was brought on by a corona virus. It has been declared a pandemic by the World Health Organization. As a result of this situation, educators all over the world were forced to make the switch to teaching students online almost immediately. Teachers and students alike are affected by this pandemic. There are many challenges for both teachers and students in online classes, including learning how to communicate effectively with each other and learning how to use technology properly (Sadeghi et al. 2014). With the Covid-19 pandemic, there are both positive and negative aspects to consider. The Indian education sector has been fundamentally altered by this pandemic. The way students are being taught in the classroom has undergone a radical transformation. Teachers can now instruct their students from the comfort of their own homes via the Internet. In order to achieve the goal of teaching and learning, teachers, on the other hand, must deal with numerous difficulties.

Teachers who have been teaching in the classroom for a long time face a major challenge when it comes to conducting online classes. As a result of the Covid-19 pandemic, the global economy is expected to suffer for the foreseeable future. As a result of the pandemic, students' educational experiences have also been impacted. Blended learning has largely taken the place of face-to-face instruction in most academic institutions. There has been a significant shift in how students perceive different teaching approaches since the Covid-19 pandemic, and it is critical that this shift be documented. As a result of the widespread implementation of Covid-19, blended learning is quickly taking hold as the norm in classrooms around the world (Salem, 2015). It's been a long time since blended learning was first introduced, and it's a combination of face-to-face instruction and online instruction all while students are still in the classroom with their teacher. Blended learning aims to give students the best of both worlds: face-to-face and online education. It's common for blended classrooms to incorporate face-on instruction methods like lectures and group discussions, but they also use technology to provide online learning that students can do at home if they have the necessary technology (Cook & Triola, 2014). A unique opportunity is provided by the Covid-19 pandemic to test student preference for face-to-face delivery in a situation where they expected it at the beginning of the semester, but blended delivery has replaced face-to-face delivery. When face-to-face instruction is replaced by blended learning, students may think they are getting a "lesser" education. The Covid-19 pandemic, on the other hand, may cause students to avoid attending lectures in person. Teachers are attracted to this model because it allows students to work at their own pace while also providing teachers with the opportunity to provide guidance when needed. Using a digital learning system and community-based projects, teachers create lessons for students based on the standards addressed in the community-based projects and other approaches (Chumley et al., 2002) and (Howlett et al., 2009).

### Objective

Listed below are the research paper's main goals

To learn about the difficulties that educators and students faced as a result of the Covid-19 pandemic. To examine the ways in which the Covid-19 pandemic has altered the ways in which teachers teach and the lives of their students. Students and teachers from various schools and universities were asked to fill out a questionnaire in order to determine the level of difficulty. People's online survey responses were analyzed and tallied. Because of the government's limitations. People seemed interested and responded with a lot of enthusiasm, as evidenced by the positive feedback we received. Students and teachers were asked about their experiences during the pandemic in the questionnaire. We were able to get a majority of their votes, regardless of whether they said yes or no and we got a very good response from 323 people of which 178 were female and 145 were male.





Khursheed Alam et al.,

Name

Gender

Male( ). Female( ). Other( )

Student/teacher

So here we represent the questionnaire:

1. It's better to use an online system for education than an offline one.
2. As a teacher, which system do you think is more effective for students?
3. Due to the pandemic, have you had to alter your study schedule in any way?
4. Do you face difficulty concentrating when taking online classes?
5. For teachers, what do you think is the most difficult part of working in an online system?
6. Did rural areas have access to the online education system during the pandemic era when educational institutions had to be closed?
7. In your opinion, was it easier to support students with emotional and behavioral disorders in an online environment than in a traditional classroom?
8. When it comes to the use of technology in the educational system, did it remain interesting over time?
9. Do you believe that online classes are an effective means of preparing students for life in the real world?
10. Even worsened, would you prefer a return to using the Internet for education?

#### Using Box Plot And Violin Plot On Our Response Data

To apply Python, we convert our data into numeric form.

We convert NO=0

YES=1

ONLINE=0

OFFLINE=1

#### Difficulties Faced by Teacher and Student

The goal of teaching is to ensure that each student receives a quality education, skills, and the ability to develop their own unique talent. Discipline and rules are enforced in the classroom by the teacher, and students feel safe and secure while learning. It's not possible to exert physical control over students in online classes. Accordingly, the researcher inquired as to whether or not online teachers face difficulties in monitoring discipline. Teaching a mathematical subject online is difficult. In the classroom, students learn mathematical concepts by writing on a whiteboard or blackboard. The teacher can write their formulas and explanations for students on the blackboard or whiteboard. If students have any questions about formulas or equations, they can ask their teacher right away. A survey was conducted to find out how difficult it is to teach numerical subjects via the Internet. In an online learner, a lack of motivation Students' motivation affects their interest, which in turn alters their behavior. It takes more effort to learn online than it does in a classroom setting. As a result of their active participation in online classes, students are more likely to grasp the course syllabus or course content. Respondents were asked if online students' lack of motivation is a challenge they face when teaching online. During online classes, students and teachers should be able to use computers and software without difficulty. No online learning or recording of visual and audio can be done without a thorough understanding of the software.

The software also had specific requirements, such as the amount of space on the operating hard disc, the latest version of Windows, and the most up-to-date graphics on the computer. Taking online classes is a form of silent harassment for both the teacher and the student without the proper knowledge. As a result, the researcher inquired as to whether or not a lack of technical and software knowledge is a factor in online education. Connectivity issues with electricity and the Internet Online classes are unable to think unless there is a strong supply of electricity and internet connectivity. In rural areas, there is no fixed time for electricity to be available. There are no Wi-Fi or broadband connections installed in rural areas because they aren't needed on a daily basis, and some people can't afford it because of its high cost. Because of this, the researcher believes that issues with electricity and internet





**Khursheed Alam et al.,**

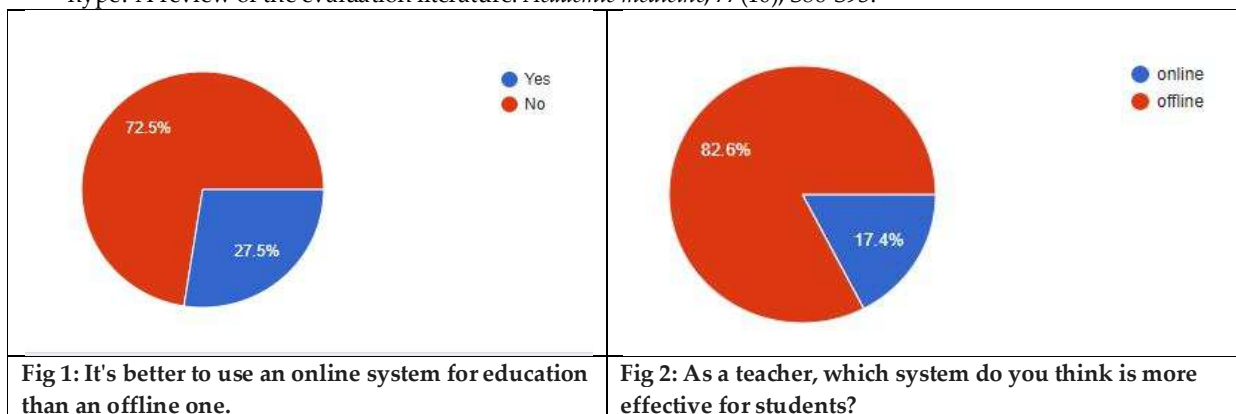
connectivity are among the most significant difficulties that educators face when providing online instruction. Motivating students can be a challenge. A person who is highly motivated always gives their all in whatever they do. They are steadfast in their dedication to their duties and never waver in their loyalty. In the absence of motivation, it is difficult for students to keep up with academics, and their performance suffers as a result. As a result, the researcher polled online instructors to see if they had trouble energizing their students.

**CONCLUSION**

As per our questionnaire, our main purpose is to find out if in any case Covid-19 or any other variant comes and creates the same situation as Covid-19 in 2020 do people want our education system converted online we got a response that 67.3% of people answered with no and 32.7% agree that education system can convert into online mode but we have to focus on the percentage of people who don't want education system convert into an online mode so through our questionnaire we have found out some problems so if those problems of students and teachers were solved by their school, college, and universities so maybe then they agree to convert the educational system into the online system.

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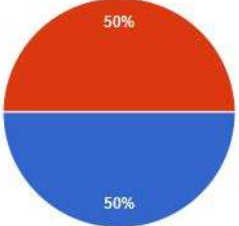
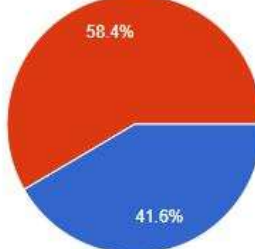
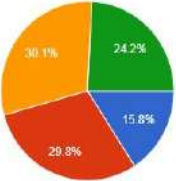
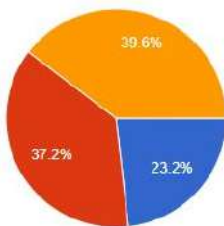
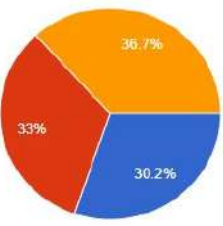
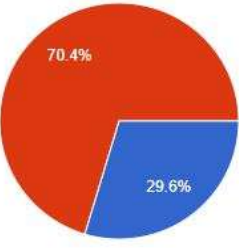
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**Khursheed Alam et al.,**

	
<p><b>Fig 3: Due to the pandemic, have you had to alter your study schedule in any way?</b></p>	<p><b>Fig 4: Do you face difficulty concentrating when taking online classes?</b></p>
	
<p><b>Fig 5: For teachers, what do you think is the most difficult part of working in an online system?</b></p>	<p><b>Fig 6: Did rural areas have access to the online education system during the pandemic era when educational institutions had to be closed?</b></p>
	
<p><b>Fig 7: In your opinion, was it easier to support students with emotional and behavioral disorders in an online environment than in a traditional classroom?</b></p>	<p><b>Fig 8: When it comes to the use of technology in the educational system, did it remain interesting over time?</b></p>





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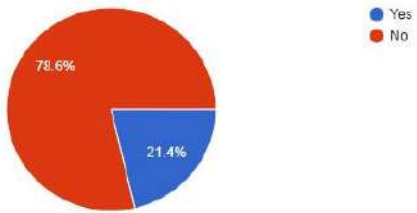


Fig 9: Do you believe that online classes are an effective means of preparing students for life in the real world?

```
In [1]: import pandas as pd
In [2]: import matplotlib.pyplot as plt
In [4]: data=pd.read_excel("D:/responses data.xlsx")
In [3]: data.head()
Out[3]:
```

Timestamp	Name	Student/Teacher	Gender	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
15-04-202_23037	AshuH	Student	Female	1	0	1	1	4	1	1	1	1	1
15-04-202_23104	AshuH	Student	Female	1	0	1	1	4	1	1	1	1	1
15-04-202_23203	Lavni	Teacher	Female	1	0	1	1	4	1	1	1	1	1
15-04-202_23736	NABUShu	Student	Female	1	0	1	1	4	1	1	1	1	1
15-04-202_014100	Divya	Student	Female	1	0	1	1	1	0	0	0	0	0

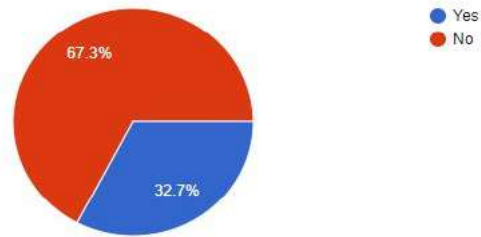
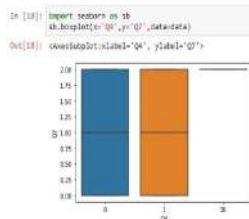
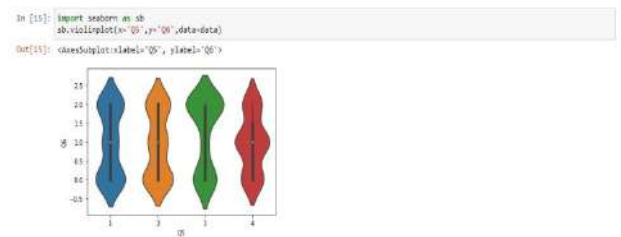
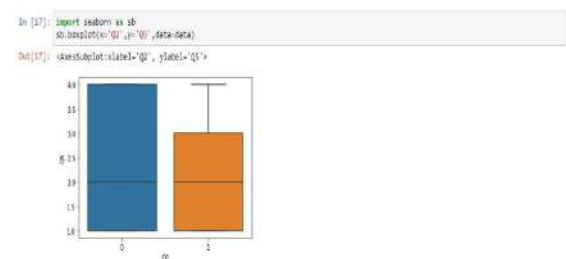
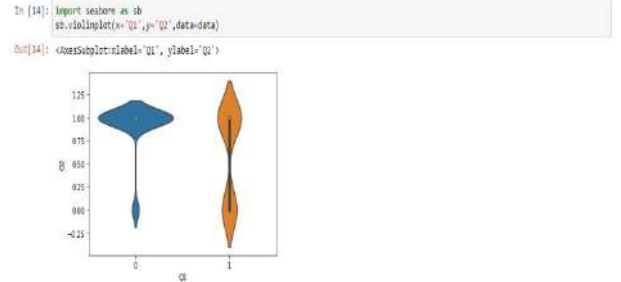
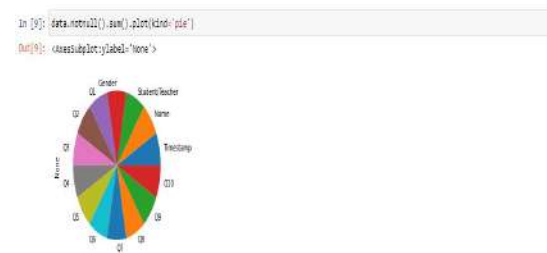


Fig 10: Even worsened, would you prefer a return to using the Internet for education?

```
In [6]: data.tail()
Out[6]:
```

Timestamp	Name	Student/Teacher	Gender	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
15-04-202_293658	Sarvesh	Teacher	Male	1	1	0	0	3	0	2	0	0	0
15-04-202_294014	abhi	Teacher	Male	0	1	0	0	3	2	2	0	0	0
15-04-202_294401	NaG	Teacher	Male	0	1	0	0	3	0	2	0	0	0
15-04-202_211818	Sajam	Teacher	Male	1	1	1	0	1	1	0	1	1	0
15-04-202_293128	Aman_pundir	Student	NaN	1	1	0	1	2	0	1	0	1	0





## Volatility Prediction of Oil and Gold Prices Using GARCH Model

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### ABSTRACT

The objective of the paper is to create a GARCH/ARCH model to predict future volatility on a rolling basis and based on it suggest recommendations related to the use of the model for risk management. The dataset is extracted from yahoo finance. The financial instruments used for the prediction were Brent Oil Futures, WTI ETF, E-Mini Oil futures, ZKB gold ETF, Micro gold futures, E-mini gold futures for energy commodities, and gold futures. The dataset has been taken from the period of August 2014 to February 2022. The dynamic GARCH model was implemented using Python. As an outcome, the Brent Oil Prices (BZ=F) GARCH (1,2), E-mini-Crude Oil Futures (QM=F) GARCH (1,0) and Wisdom Tree WTI Crude Oil (CRUD.MI) GARCH (1,1) model was applicable and showed better results as compared to other GARCH models. In the instance of gold prices, Micro Gold Futures (MGC=F) GARCH (1,0), E-Mini Gold Futures (QO=F) GARCH (1,2), ZKB Gold ETF (ZGLD.SW) GARCH (1,1) was applicable and predicted accurate results with fewer errors.

**Keywords:** Volatility Prediction, GARCH model, Gold Price, Oil Price, Rolling forecast, PACF.

### INTRODUCTION

Stories on crude oil prices, future prices, volatility, etc. are common in financial news. This is because every business depends on energy commodities for production, storage, and logistics. Therefore, production and storage both require electricity which for the most part is still a result of energy commodities that are formed from fossil fuels. Additionally, crude oil is still a staple for logistics and transportation. Hence every industry is directly correlated to the price of crude oil. This means that it is in the best interest of most businesses to be able to get a stable price on these energy derivatives. The aviation industry, transportation, and logistics industry, and maritime industry are examples of industries that are heavily dependent on the price of energy commodities, so much so that companies are often forced to face bankruptcy due to volatility in the energy commodity prices. So, it is pivotal for companies





Piyush Kumar *et al.*,

to be able to obtain a fixed price for energy commodities do not face the risk of their price volatility; This is often achieved through models to predict the future prices of the energy commodities or using energy derivatives like Futures, Options and Forwards. Energy Commodities affect other commodities, and they also have a degree of correlation with each other. Power supplies like crude oil, natural gas, and coal are all aimed at power generation which directly affects the production of all other commodities. Additionally, crude oil is stapled in the transportation business as no alternate fuel has taken away the dependency on oil as fuel. Currently, gas prices in the US are at an all-time high along with the inflation rate. The US inflation is currently 4.3% as per the International Monetary Fund. Due to high inflation soon, the US will be using its reserves due to which the prices hike will be more. Thus, a scenario of economic collapse can be seen. Gold, on the other hand, is the most precious metal among all other metals like silver, diamond, and platinum to name a few. As of the year 2021, the United States of America holds 8133.47 tons of gold reserves followed by Germany holding around 335.09 tons of gold reserves. India holds around 754.10 tons of gold reserves which is 9<sup>th</sup> in the whole world.

Western Europe consists of 11 thousand tons of gold followed by the US. Venezuela holds a maximum gold reserve as of the year 2021 of 82.9% followed by Portugal with 68.64%. The United States of America holds around 66.28% of gold whereas India holds only 6.86% of the gold. (*Central Bank Holdings, 2022*) Thus, gold becomes a vital metal during foreign exchange, the international monetary system, etc. The value of gold directly influences the currency of the nation that exports and imports the gold. Thus, if the country exports gold its currency strength becomes stronger. Thus, the country exporting gold will be surplus in nature and will be able to offset the trade deficit. Thus, gold is widely used for hedging, diversification of the portfolio, source of wealth, and as a safe asset for the stock market during times of trouble. This paper will create a GARCH (Generalized Autoregressive Conditional Heteroskedasticity), or ARCH (Autoregressive Conditional Heteroskedasticity) model based on PACF (Partial Autocorrelation Function) to find the required ' $\alpha$ ' and ' $\beta$ ' values. Energy futures, gold futures, and their historic data are used for the creation of the model. The model is then tested using historic data to find its accuracy. Finally, in the end, the model is used to predict future volatility on a rolling basis. Based on the results, recommendations on the use of the model to hedge energy commodity prices and gold prices risks are suggested.

## LITERATURE REVIEW

(X. Chen *et al.*, 2022) In this paper, the researchers have used the concept of the FIGARCH model in an improvised way for time-varying volatility prediction. The dataset used in the paper was taken from S&P500 and Brent crude oil regular shutting prices from 01/01/2010 to 01/04/2020. The total sum of observations for Brent crude oil was 2888. The three models were applied in both the dataset and then the results of the same were compared with each other. As an outcome, the FIGARCH and FIGARCH-C versions bettered the GARCH version in apprehending the length retention in volatility. The FIGARCH-C version adjusts accurately in actual situations It was also discovered that the FIGARCH-C model was further complex to capture the change during the unpredictable period owing to the consequence of the small change built on the Caputo small derivative. (Lubis *et al.*, 2021) In this article the authors have focused on determining the influence of variations in crude oil prices, and trade rates on the unpredictability and gold prices of the Jakarta Composite Stock price all through the SARS-CoV-2 epidemic. Mathematical techniques such as graphic study was used broadly during the study timeframe. A goal-directed random sample method was used to collect the samples. The data on the rupiah exchange of the dollar was also taken for the research. The dataset was taken from 02/03/2020 to 25/03/2021 from Data-stream at Eikon Faculty of Economics of Andalas University. The dataset acquired contained 275 trials. The authors use the method of the GARCH/ARCH model. Using the model, it was found that there was a noteworthy positive consequence on the JCI while for the crude oil and trade rate there weren't any major changes in the rates. (Huang & Wu, 2021) In this article, the researchers have identified the asymmetries in oil and gold costs during the corona virus epidemic. The authors have used VAR (p) – BEKK – AGARCH (1,1) version on the regular oil as well as gold prices. NYMEX WTI and XAUUSD index is used to get a dataset of crude oil prices and gold values respectively. The dataset was collected from 27/06/2018 to 25/06/2021. The complete sample of 751 observations was taken after cleaning the missing values.





**Piyush Kumar et al.,**

As an outcome, it was shown that negative information and the widespread corona virus have an overall bad impact on the oil and gold return volatility. The outcomes show no mutual gain or volatility deluge conclusions relating the oil and gold marketplaces during the corona virus epidemic. (Atri *et al.*, 2021) In this article, the authors have investigated the effect of corona virus, fear, as well as media leading to decreasing trends in oil and gold values. The authors have used the ADRL approach. The dataset was collected for the timeframe of 23/01/2020 to 23/06/2020. The authors use the West Texas Intermediate (WTI) oil prices information which was extracted from the US resources information administration while the data of daily gold prices were taken from the website named "investing.com". In total, 124 samples were collected after cleaning the missing values. The outcome also shows that the monetary and fiscal ambiguity affected oil and gold values adversely in the pandemic. (ozturk&cavdar, 2021) In this article, the authors have investigated the effect of COVID-19 on the unpredictability of Bitcoin, gold price, oil costs, and exchange rates and the relationship between and key features during the pandemic. The authors have used the concept of the ARIMA-EGARCH version to evaluate the effect of volatilities and upsets on financial features.

The collected data is from the time frame of 02/09/2019 to 20/12/2020. It can be said that the outcomes found suggested that it significantly affects the conditional variability of the variables. (Yousef & Shehadeh, 2020) In this paper, the authors have examined the effect spread of corona virus on gold spot values. The researchers have used the GARCH and GJR – GARCH models. The dataset used was of daily gold prices from the time frame of 2012-2020. The authors found a confirmed relationship linking the growing figure of COVID occurrences as well as the increasing gold value. As the forthcoming remains uncertain with the widespread corona virus, the claim for gold is high which is pushing the price up. (Gharib *et al.*, 2021) In this article, the researchers have examined the correlation relating gold spot values as well as oil values and the influence of the corona virus. The authors have used the West Texas Light raw oil data and gold values data for analysis. The dataset is from the time frame 04/01/2010 to 04/05/2020. The oil price dataset is supplied by the United States Energy Information Administration (EIA) as well as the gold value data was extracted from the website named "www.gold.org". They have found the mutual infection consequence of effervesce in oil as well as gold marketplaces during the pandemic. (Vidal & Kristjanpoller, 2020) In this article, the researchers have predicted the unpredictability of gold costs. The researchers have applied LSTM and VGG-16 architecture to conduct the prediction of the volatility of gold prices. The dataset used in this research was extracted from London Bullion Market Association containing daily gold spot prices. The dataset was from the time frame of 04/1968 till 10/2017. The dataset contained 12350 samples. A 37% reduction in mean square error is detected compared to the GARCH model whereas 18 percent in comparison to the LSTM model. (Fałdziński *et al.*, 2020).

In this article, the authors have compared the volatility of futures contracts of resources goods like Natural oil, natural gas, gasoline, gasoil, and warming oil. The authors have conducted a comparison between the GARCH model and the SVR (Support Vector Regression) model. The authors have taken the WTI energy dataset for raw oil, gasoline, warming oil, and natural gas and gas oil. The authors have taken data from the period of 02/01/2015 to 31/12/2019. According to the researchers, the SVR model takes a smaller number of hyper-parameters thus reducing the chance of errors as compared to the GARCH model. The authors found that the SVR version has the lowest MSE and MAE in 92% of the cases whereas the asymmetric GARCH model gives more accurate results in most of the cases too. (Zhang *et al.*, 2020) In this article, the researchers have predicted the accuracy of the energy future index using the LSTM (long short-term memory) network. For the research, the authors have adopted data from six different groups. This includes Brent, WTI, HO, LGO, MNG, and NCF. This dataset contains 2000 observations. (R. Chen & Xu, 2019) In this article, the researchers use the multivariate GAS algorithm to predict the volatilities and correlation among Brent, WTI, and gold values. The fluctuating multivariate Generalized Autoregressive Score (GAS) algorithm is defended by the Doornik- Hansen test. The authors have used the raw dataset of WTI crude oil, Brent, London gold values daily. The dataset used in this article was from the time of 02/01/2003 to the period 19/01/2018. The valuation results demonstrate that the multivariable GAS method describes the unpredictability maintenance as well as non-linear interface consequences relating the crude oil as well as gold markets plus this model was compared with DCC-GARCH model.





Piyush Kumar *et al.*,

## RESEARCH METHODOLOGY

The research is done to design a GARCH or ARCH-based model with different ' $\alpha$ ' and ' $\beta$ ' values. These values are required to find the alpha and beta variables that were significantly correlated with the data. Generally, these values differed for different markets and commodities irrespective of the model and its parameters. The model is created using *Python* language. This enables the use of machine learning along with already established libraries to enable the model to crunch big data sets at a relatively fast pace and analyze the same. Multiple times were utilized to better understand the impact of data set size and duration on the efficacy of the model.

### Dataset

The dataset of Brent crude oil, WTI crude oil, daily spot values of gold prices from E-mini gold futures, and ZKB gold ETFs has been taken. The oil data was predicted for 1st Jan 2014 to 1st Jan 2022 while that of gold prices was predicted from 1st Jan 2014 to 24th February 2022. The dataset will be divided into various periods 1 month, 3 months, 6 months, 1 year and 3 years. The dataset for oil and gold values is extracted from yahoo finance and google finance.

### Workflow of the Research

In this section, the authors describe the stages of research work conducted. Figure 1. Represents different steps involved during the work.

**Data Acquisition** The dataset of Brent crude oil, WTI crude oil, E-mini gold futures, ZKB gold ETFs, and others from investing.com was taken.

**Data cleaning** The null values from the dataset were removed.

**Data analysis** The cleansed data was applied for analysis and to perform visualization.

**Model training** The GARCH model was trained.

**Model testing** Model testing was done based on the training of the model. Accuracy was taken as the metric to test the model.

**Prediction** Fore cast was made based on the testing data models.

**Evaluation** The algorithm was assessed at the last resulting in the true outcome of the research.

### GARCH model

GARCH model or Autoregressive Conditional heteroscedasticity model will be used to predict and forecast volatility of the energy futures based on both normal and rolling on basis. The rolling on basis utilized new information to better change its forecast and prediction making it dynamic as it can easily add newer information to make the model's result superior. The rolling on predictions will also be done in different time periods to elevate and test for effects of longer time periods on the accuracy of the forecasts and predictions of the model. The formula of the GARCH model is given in the Eq.1.:

$$a_t = \varepsilon_t \sqrt{\omega + \alpha_1 a_{t-1}^2 + \alpha_2 a_{t-2}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2 \sigma_{t-2}^2 \dots} \quad (1) \text{ where } a_0, a_1 \sim \mathcal{N}(0,1); \sigma_0 = 1, \sigma_1 = 1 \text{ and } \varepsilon_1 \sim \mathcal{N}(0,1)$$

### Partial auto correlation function (PACF)

PACF will be used because of its characteristics in analysis of time series especially when considering the stationary time series and their lagged values, regressed values at even smaller period of lags. PACF is taken instead of ACF – Autocorrelation Function because unlike ACF, PACF has an aspect of control of lags. For the given time series,  $z_t$  the partial correlation of  $\log k$  also denoted as  $\alpha(k)$  is nothing but the autocorrelation between  $z_t$  and  $z_{t+k}$  with the linear dependence of  $z_t$  on  $z_{t+1}$  through  $z_{t+k-1}$  was removed. Equivalently, it is the correlation between  $z_t$  and  $z_{t+k}$  that is not accounted for by lags 1 through  $k-1$ , inclusive as shown below in Eq.2 and Eq.3.

$$\alpha(1) = \text{corr}(z_{t+1}, z_t), \text{ for } k = 1 \quad \dots (2)$$

$$\alpha(k) = \text{corr}(z_{t+k} - P_{t,k}(z_{t+k}), z_t - P_{t,k}(z_t)), \text{ for } k \geq 2 \quad \dots (3)$$







**Piyush Kumar et al.,**

Where  $P_{t,k}(x)$  is the surjective operative of rectangular estimate of  $x$  onto the true subspace of Hilbert space spanned by  $z_{t+1}, \dots, z_{t+k-1}$  (Partial Autocorrelation Function, n.d.)

### Analysis

After the data was extracted, it was cleaned and divided into various periods 1 month, 3 months, 6 months, 1 year, and 3 years. The dataset was extracted from Yahoo Finance and Google Finance. The dataset before the pandemic and during the pandemic was also used to better recognize the effects of the corona virus pandemic on the model as the increased volatility might affect the aspect of the model.

### Brent crude oil last day finance (BZ=F)

The market historical data had been taken from Yahoo Finance and the period considered for training the model is from August 2014 to February 2022. The year 2022 is used to compare the results of the model to the actual results. A rolling forecast is done by the model using basic machine learning techniques to add modifiers for extreme changes to predictions to modify its forecast. Firstly, the Partial Autocorrelation Function (PACF) of the data was found as shown in Figure 2. The PACF Shows a high correlation that then falls and rises till 2nd variable. Based on this test on GARCH (1,1), GARCH (2,2) and GARCH (4,4) was done to find the best variables and hence the model based on the significance of the variables. This significance was considered based on a P-test where the P values were needed to be above a 95% confidence interval. When GARCH (1,1) was tested, it was found that the P value for Beta [1] is absolutely zero which is not possible, and the coefficient of Alpha [1] is less than the taken value thus from both cases, GARCH (1,1) is not suitable. **GARCH (1,2)** As in Table 1, the GARCH (1,2) has all its variables having a small P value with very little standard error and high confidence intervals, it was selected as the volatility model for the Data Set. Based on the GARCH (1,2) model, the model was trained on historic data and then it was used to forecast the volatility for the period 1st Jan 2014 – 1st Jan 2022. Additionally, the model was also used to forecast the volatility levels for the upcoming 7 days. As demonstrated in Figure 3(a), the unpredictability prediction on a rolling basis for the Brent Crude Oil dataset. Figure 3(b) shows the volatility prediction for the next 7 days.

### E-mini-Crude Oil Futures (QM=F)

E-mini are fraction-cost investment instruments that generally are products of futures and are found in the Chicago Mercantile Exchange. These are smaller in size than actual futures making them accessible to funds and individuals that are of smaller sizes. This means that the instrument has a higher degree of efficiency because of its accessibility. The Partial Autocorrelation Function for QM=F is shown in Figure 4. Based on the Partial Autocorrelation Function of the E-Mini, we can see that a GARCH (1,1) or a GARCH (2,2) volatility model would be most appropriate. Hence to select the right volatility model, a P-test for the proposed models is done. When GARCH (1,1) was tested it was found that, in GARCH (1,1) all  $\alpha$  and  $\beta$  variables have high p values suggesting that the variables are no longer significant enough. Thus, we tested, GARCH (1,0) and it showed that - **GARCH (1,0)** Based on above table 2, the GARCH (1,0) model is selected for the forecasting of volatility. Based on the same it can be seen in Figure 5(a) the volatility prediction on the rolling forecast and Figure 5(b) shows the volatility of the next 7 days which is rising high. These are the actual returns vs the forecasted returns for the data set and the predicted future 7-day returns of the volatility.

### Wisdom tree WTI crude oil (crud. Mi)

Wisdom Tree is one of the pioneers in the ETF space and one of the leaders in ETF funds in the USA. Hence as WTI futures are shorter term than the size of the data set, this ETF of the WTI crude oil will help provide a proxy for the Western Texas Intermediate (WTI) crude oil values. Based on the same, the Partial Autocorrelation Function of the data set was first discovered and is shown below in Figure 6. Based on the PACF, the link between the  $\alpha$  and  $\beta$  Move up and down so up till GARCH (4,4) model would be most suited but a GARCH (3,3) can be checked up till a GARCH (4,4) if the P values suggest the same could be significant. Based on this below are the results of the volatility model's P values. **GARCH (1,1)** Table 3 shows the GARCH (1,1) for CRUD.MI, all standard errors are less, and P values are also equal to 0. Thus, it can be said this GARCH (1,1) is a good model for prediction volatility. The GARCH (4,4) models showed high P values indicating that a GARCH (1,1) is ideal for forecasting volatility in this





Piyush Kumar et al.,

case. Based on the same forecasting volatility for the time of 1st Jan 2014 till 1st Jan 2022 is shown along with the actual returns and then the next 7 days' predicted volatility is also shown in Figure 7(a) and Figure 7(b) respectively. The above model forecasting clearly shows the volatility of the asset to a higher degree of accuracy, predicting an upcoming increase in volatility for the next 2 days and a decrease in volatility before that. Hence this model can be used to accurately forecast future volatility of the underlying or even similar assets like stocks that function similarly in terms of volatility movement.

#### Micro gold futures (MGC=F)

Micro gold futures are a future instrument till Jun 2022. The symbol is MGC=F. The future is traded in the USD under the COMEX group which offers a benchmark too. This evaluation is done for the time of 1st Jan 2014 – 28th Feb 2022. Firstly, the PACF model has been found for the same period as shown below in Figure 8. Based on the PACF, GARCH (7,7) can be best suited for this dataset. Based on the P values, the following GARCH values are present. The P values are nearly equal to zero and the beta value of it is absolutely zero in GARCH (1,1). Thus, looking at the above table we check the a and b values for GARCH (7,7). This GARCH (7,7) was highly insignificant and consisted of high values thus one more test of GARCH (1,0) was also done. **GARCH (1,0)** From table 4, P values are smaller in both cases, standard errors are also less thus this GARCH (1,0) is better than GARCH (1,1) and GARCH (7,7). Thus, based on the GARCH (1,0) model, the rolling forecast and volatility of the future are predicted for the next 7 days as shown in Figure 9(a) and Figure 9(b) respectively. As from the above picture, the volatility is rising and from the third day, it is very constant due to the Russia-Ukraine war. In the rolling volatility, not much volatility has risen but in the year 2020, the volatility has risen due to black swan events.

#### E-mini gold futures (QO=F)

E-Mini gold futures is a future instrument till Jun 2022. The symbol is QO=F. The future is traded in the USD under the COMEX group which offers a benchmark too. This evaluation is done for the period of 1st Jan 2014 – 28th Feb 2022. Based on the PACF model, after the 3rd value it can be seen in Figure 10 that the graph is rising again. Hence GARCH (1,1), and GARCH (4,4) can be used for prediction. GARCH (1,1) P values were quite small with a beta [1] value of absolute zero. GARCH (4,4), GARCH (1,2), and GARCH (2,2) were also tested. GARCH (4,4) had a lot of insignificant and the values are bigger. Thus GARCH (1,2) was checked. **GARCH (1,2)** From table 5, GARCH (1,2) values of alpha and beta are highly significant, and the P values were nearly very significant. GARCH (2,2) when tested showed high values of P which was highly insignificant. Thus, based on the GARCH (1,2) model, rolling volatility and volatility for the next 7 days were predicted. From figure 11(a), it was found that volatility based on rolling forecast was high during the year 2016-17 and 2020-2021 period. Further, from Figure 11(b) the volatility prediction for the next 7 days was higher due to Russia-Ukraine ongoing War, high inflation in the United States, etc. In the rolling prediction from 2017 to 2020 the volatility was stable but during the COVID-19 pandemic, the volatility was relatively high.

#### ZKB Gold ETF (ZGLD.SW)

ZKB gold ETF is an ETF instrument traded in the Swiss stock market. The symbol is QO=F. The ETF is traded in the CHF or SWISS franc. This evaluation is done for the period of 1st Jan 2014 – 28th Feb 2022. Based on the PACF model, after the 4th value it can be seen in Figure 12 that the graph is rising again. As, it can be seen from table 6, the best-fit model for this is GARCH (1,1) because when GARCH (5,5) was tested it showed it was highly insignificant. Thus, based on the GARCH (1,1) model, the rolling volatility prediction and volatility of the next 7 days are predicted. As from Figure 13(a), despite the war scenarios between Russia and Ukraine, the volatility of gold prices is declining for the next 7 days while according to Figure 13(b), there was a sudden peak in gold prices in the year 2020 due to black swan events.

## DISCUSSION

The conducted research is comprehensive, but the scope of the research has limitations and the same are discussed in this section. Firstly, the fact that the GARCH model is used means that the model is heavily based on ARMA –





Piyush Kumar et al.,

'Auto Regressive Moving Averages' to forecast. This limits its performance to the performance of the process of ARMA. Additionally, the literature suggests that a dynamic GARCH model can perform better than the traditional GARCH models and this is done by implementing a rolling prediction methodology over a static prediction methodology. Since it is a software-generated outcome; the output is the product of the input and can't be influenced by other factors; Hence, any other factors must be applied to the output there after. In comparison to ARCH-based models, GARCH models have a longer-lasting effect on the model. This makes GARCH more desirable when it comes to the prediction of volatility for assets like stocks and futures. However, the model is not capable of predicting black swan events or world events that can impact volatility. This means that the model acts as a lagging factor to big events that push volatility. The data set taken in the study is during 2014 – 2022 containing time basis. 2014 – 2020 was a period of continuous bull run meaning that the data set is influenced by this factor. After 2020 the black swan event and the currently on-going war are taking place. In this paper, the effect of black swan events is also predicted but the war events on the model are yet to be discovered.

### RECOMMENDATION

The model has proved its effectiveness in predicting and forecasting future volatility for energy futures and gold futures. Additionally, this capability of the model at predicting volatility of energy futures and gold futures has been tested on historic data and that too at multiple energy commodities futures and gold futures-related assets like the WTI ETF, E-Mini Futures, actual Brent Crude futures, ZKB ETFs, E-Mini gold futures, and Micro Gold futures. Hence, this model can be utilized for forecasting multiple energy commodities futures and gold futures. Often when purchasing energy commodities or futures, there is an aspect of price risk that there is a risk of getting an unfavorable price due to short-term volatility. This model can help predict price volatility which has a high degree of accuracy for a short period. This enables the use of the predicted volatility to get a better idea about the increase or decrease in volatility to better understand and gauge price risk and act as an alternative to SIPs. The model can predict long-term volatility but to a less accurate extent. It can predict the direction of volatility in the long term but not the variance in the long term. This means that even though the values of volatility lose accuracy over some time they can still provide insights about the long-term trends of volatility.

This aspect of the model can be utilized to predict the trend of volatility for both the medium and long term. This can help predict the level of risk that the commodity has and in what direction it is moving. Hence, this can be utilized to forecast the needs and size of the hedge if investments in these commodities are likely to either increase or decrease over the medium or long term. This also means that it can help provide insights about medium- and long-term risks and in doing so enable additions of support modifiers for models that get affected by changes in volatility of the underlying asset for the models. Finally, even though the model can't predict war-like events and their impact on volatility, it can still predict the future based on a lagging modifier. The model has an aspect of rolling prediction which means that it can utilize new information to modify its forecasts on a rolling basis meaning that in case of a black swan event, the model can adjust its forecasts to it quickly providing quick forecasts of the new volatility levels that would be the result of the war-like event. This forecast will also increase in accuracy with an increase in the provided information, meaning that it becomes more accurate as we move further from the war-like event.

### CONCLUSION

The paper focuses on the prediction of energy futures and gold futures for better risk management. The dataset used for model prediction has been taken from yahoo finance and the financial instruments used for the prediction were Brent Oil Futures, WTI ETF, E-Mini Oil futures, ZKB gold ETF, Micro gold futures, E-mini gold futures for energy commodities and gold futures. The dataset has been taken from the period of 01/01/2014 – 01/01/2022 for prediction of oil price volatility while for the gold value, the dates were taken from 01/01/2014– 28/02/2022. The dynamic GARCH model was implemented using Python. For oil price volatility predictions, the Brent Oil Prices (BZ=F) GARCH (1,2) model was applicable, while for E-mini-Crude Oil Futures (QM=F) GARCH (1,0) and Wisdom Tree





**Piyush Kumar et al.,**

WTI Crude Oil (CRUD.MI), GARCH (1,1) was applicable and showed better results as compared to other GARCH models. For gold prices, Micro Gold Futures (MGC=F) GARCH (1,0) was applicable, for E-Mini Gold Futures (QO=F) GARCH (1,2) was applicable and for ZKB Gold ETF (ZGLD.SW) GARCH (1,1) was applicable and predicted accurate results with fewer errors. Although the model can't predict war-like events and their impact on volatility, it can still predict the future based on a lagging modifier. The model has an aspect of rolling prediction which means that it can utilize new information to modify its forecasts on a rolling basis meaning that in case of a black swan event, the model can adjust its forecasts to it quickly providing quick forecasts of the new volatility levels that would be the result of the war-like event.

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**Table 1: GARCH (1,2) for BZ=F**

	Coefficients	Std. Error	T-test	P >  T	95% Confidence Interval
Omega	0.0899	3.516e-02	2.556	1.058e-02	[2.097e-02, 0.159]
Alpha [1]	0.1401	3.123e-02	4.486	7.271e-06	[7.887e-02, 0.201]
Beta [1]	0.3270	0.164	1.993	4.625e-02	[5.438e-03, 0.649]
Beta [2]	0.522	0.146	3.579	3.443e-04	[0.236, 0.809]





**Piyush Kumar et al.,**

**Table 2: GARCH (1,0) for QM=F**

	Coefficients	Std. Error	T-test	P >  T	95% Confidence Interval
Omega	3.5317	0.430	8.221	2.021e-16	[2.690, 4.374]
Alpha [1]	1.000	0.490	2.039	4.140e-02	[3.898e-02, 1.961]

**Table 3: GARCH (1,1) for CRUD.MI**

	Coefficients	Std. Error	T-test	P >  T	95% Confidence Interval
Omega	0.0926	3.692e-02	2.507	1.216e-02	[2.021e-02, 0.165]
Alpha [1]	0.0724	1.696e-02	4.268	1.971e-05	[3.915e-02, 0.106]
Beta [1]	0.9060	1.872e-02	48.391	0.000	[0.869, 0.943]

**Table 4: GARCH (1,0) for MGC=F**

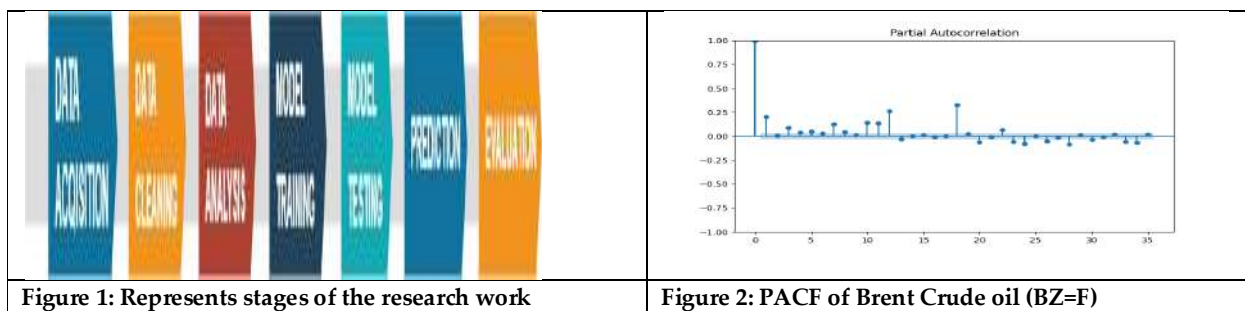
	Coefficients	Std. Error	T-test	P >  T	95% Confidence Interval
Omega	0.8046	4.725e-02	17.028	5.119e-65	[0.712, 0.897]
Alpha [1]	0.0471	2.649e-02	1.777	7.652e-02	[-4.855e-03, 9.898e-02]

**Table 5: GARCH (1,2) for QO = F**

	Coefficients	Std. Error	T-test	P >  T	95% Confidence Interval
Omega	0.0127	6.156e-03	2.00	3.842e-02	[6.798e-04, 2.481e-02]
Alpha [1]	0.0813	3.093e-02	2.628	8.590e-03	[2.066e-02, 0.142]
Beta [1]	0.7379	0.373	1.980	4.765e-02	[7.649e-03, 1.468]
Beta [2]	0.1563	0.343	0.455	0.649	[-0.516, 0.829]

**Table 6: GARCH (1,1) for ZGLD.SW**

	Coefficients	Std. Error	T-test	P >  T	95% Confidence Interval
Omega	0.0172	1.224e-02	1.402	0.161	[-6.829e-03, 4.115e-02]
Alpha [1]	0.0825	2.313e-02	3.566	3.621e-04	[3.715e-02, 0.128]
Beta [1]	0.8975	3.492e-02	25.698	1.222e-145	[0.829, 0.966]







**Piyush Kumar et al.,**

<p style="text-align: center;">(a)</p>	<p style="text-align: center;">(b)</p>	<p style="text-align: center;">Partial Autocorrelation</p>
<p><b>Figure3(a)Volatility prediction - rolling forecast of GARCH (1,2) for BZ =F; (b)Volatility prediction for Next 7 days of BZ=F</b></p>	<p><b>Figure4: PACF of E-mini-Crude Oil Futures (QM=F)</b></p>	
<p style="text-align: center;">(a)</p>	<p style="text-align: center;">(b)</p>	<p style="text-align: center;">Partial Autocorrelation</p>
<p><b>Figure5(a): Volatility prediction - rolling forecast based on GARCH (1,0) for QM=F, Figure 5(b): Volatility Prediction for next 7 days of QM=F</b></p>	<p><b>Figure6: PACF of Wisdom Tree WTI Crude Oil (CRUD.MI)</b></p>	
<p style="text-align: center;">(a)</p>	<p style="text-align: center;">(b)</p>	<p style="text-align: center;">Partial Autocorrelation</p>
<p><b>Figure 7(a): Volatility Prediction on rolling forecast based on GARCH (1,1) model, Figure 7(b): Volatility Prediction for Next 7 days for CRUD. MI</b></p>	<p><b>Figure8: PACF of Micro Gold Futures (MGC=F)</b></p>	
<p style="text-align: center;">(a)</p>	<p style="text-align: center;">(b)</p>	<p style="text-align: center;">Partial Autocorrelation</p>
<p><b>Figure 9(a): Volatility Prediction on rolling forecast for MGC = F; Figure9(b): Volatility prediction for next 7 days based on GARCH (1,0) for MGC=F</b></p>	<p><b>Figure 10: PACF for E-Mini Gold Futures (QO=F)</b></p>	







Piyush Kumar et al.,

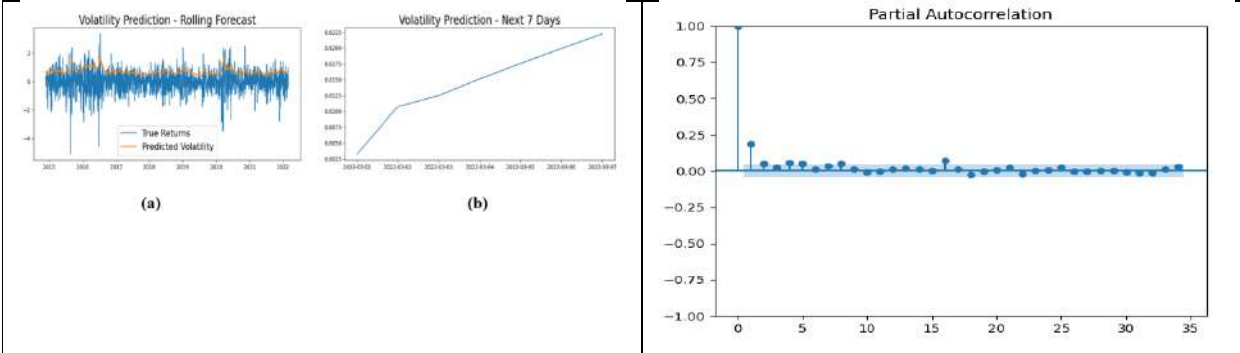


Figure 11(a): Volatility Prediction on rolling forecast based on GARCH (1,2) for QO=F; Figure 11(b): Volatility prediction for next 7 days for QO=F

Figure 12: PACF of ZKB Gold ETF (ZGLD.SW)

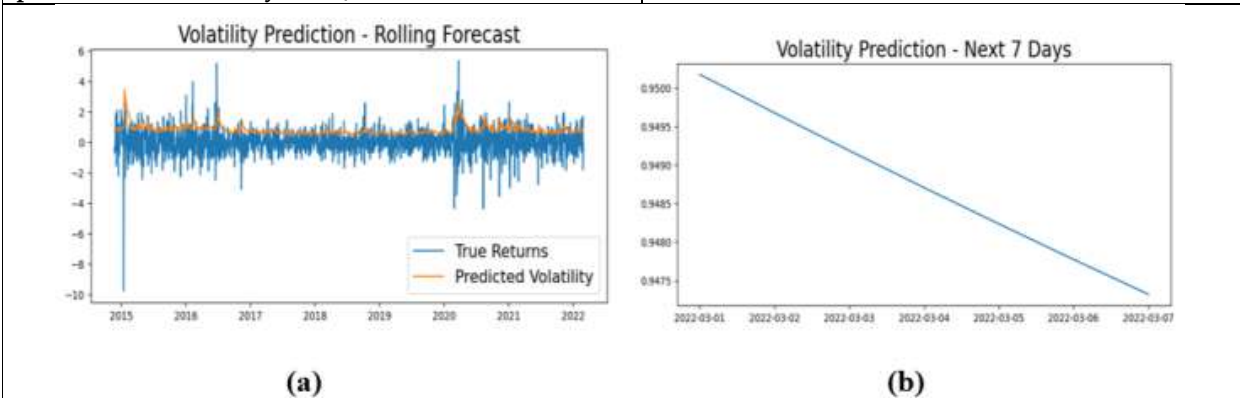


Figure 13(a): Volatility Prediction on Rolling forecast for ZGLD.SW; Figure 13(b): Volatility Prediction for next 7 days based on GARCH (1,1) for ZGLD.SW





## A Comprehensive Review and Classification of Numerical Methods for American Options Pricing

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### ABSTRACT

This research paper provides a comparison and classification of methods employed in the pricing of American options. American options, due to their flexibility in exercise timing, pose a complex challenge in financial mathematics. Various numerical techniques have been developed to address this challenge, each with its advantages and limitations. This paper aims to categorize and analyze these methods based on their underlying principles, computational efficiency, and accuracy.

**Keywords:** Pricing American options. Flexibility, accuracy, efficiency

## INTRODUCTION

American options, unlike their European counterparts, grant the holder the right to exercise at any point before expiration. This feature adds a layer of complexity to their pricing, necessitating the use of numerical methods. American call option works same as European call option but there is a difference between European put option and American put option because of the early exercise property of American Options [17]. The early exercise property gave rise to open boundary problem for American Put Option problem which makes it difficult to price. The foundation for option valuation was laid by Louis Bachelier a French mathematician in 1900 in the work done for his PhD thesis. Bachelier introduced Brownian motion for option pricing. Later Black F. and Scholes M. invented mathematical model for option pricing, which brought a rush to financial markets. Their work together with Merton R.C. [1] won a Nobel Prize in 1997, but by then Black F. was no more and hence it was received by Scholes M. and Merton R.C. in 1997. American put option is difficult to price due to its open boundary problem as the time to exercise the option is not fixed it can be done any time before the Exercise time. Several methods were used to price American options like, Binomial tree model, Finite Difference Method, Finite Element methods, Wavelets method, Monte Carlo methods, Fast Furrier transforms, Inverse volatility method, Front fixing method[13], Fractional Derivative method, Method of lines, Regime switching model, Neural Network method for pricing American put option[2-9]. The asset price dynamics were studied with the help of martingale concept and although there was a hypothesis 'that the current price of an asset is the best estimate of its future value', it proved to be not entirely correct as it meant that

70474





**Poonam Deshpande and Khurshed Alam**

one can entirely depend on the past performance of the financial markets to predict the future. But Fisher and Lorie [1] showed that even randomly selected data can also considerably predict the future stock prices and give good return on the investments. During 1970s and 1980s uncertainty characteristic and the valuation of options became the decision makers. And during this period more scientists started working in this field namely Sharpe-Linter and Solnik (1974) etc. [1]. The mathematical tools such as Partial Differential Equations, Stochastic Differentiation, Stochastic Dynamic programming became mind-numbing. In this period of development of 'Mathematical Finance' the most important discovery was made by Black F. and Scholes M. by introducing their 'Black-Scholes model' for option pricing. Later it was extended by Merton R.C. [1].

It was literally on the day the model was published, the trading of options was listed by Chicago Board of Options Exchange (CBOE). Black-Scholes model was so useful that, there was a calculator created by Texas instruments, which gave values of hedging and option price. It actually kick-started professional use of Mathematics models in Finance. Black-Scholes model was appreciated mainly because it was based on noarbitrage policy, so that both parties of the contract would benefit from the deal. It also took care of volatility of returns with the help of measure of variation tool i.e. standard deviation. Options like 'American options' were taken care of by Black-Scholes model, it being non-linear in nature. They used the 'replicating portfolio approach' for the same [1]. This actually led to a sophisticated use of the mathematical models in finance. The users of these models in 1970s were major players in the US financial markets, such as US institutional equity investors, market makers, brokers trading US equity options and many more [1]. we feel that the future of mathematical modelling is going to be tough for the researchers and also for all those who have entered this field in recent times in a sense that there is a fantastic past to the mathematical modelling and the question is now what more can be done to make them even more superior, so it will be definitely more challenging and engaging. Easy access to the scholarly articles in this area, technological superiority and availability of all the required resources at finger tips should actually give an upper hand to all the researchers in recent times. The objective of this research is to categorize and evaluate the diverse numerical approaches available for pricing American options.

### Background

This section provides an overview of American options, emphasizing the challenges associated with their valuation. It also highlights the importance of numerical methods in addressing these challenges. The foundation of the mathematical finance or let us make it more generic and say that the foundation of the option theory is on one question that 'What price to be paid now for an Option to buy or sell in the future at a prescribed time'. Option is a contract that gives right but not the obligation to buy or sell in the future at a particular time. Black, F. at. el. [6] discusses about difference between American and European option and also that the option that gives right to buy a single share of stock is the simplest one. They have also introduced terminology for option pricing, like what is the strike price and maturity time etc. Throughout the paper till valuation they are referring to only call option unless otherwise stated. From the discussion it is clear that the one who wants to opt for the call option is anticipating that the stock price will increase and the one who wants to opt for put option wants the asset price to fall. The valuation of option is such that the holder of the option will either exercise the option or the option becomes worthless. They also mention that the maturity date must not be far away or very near in the future, as only then an option price will be fair. While mentioning the previous work done by various researchers on the valuation of options, which were lacking in one or the other aspects. Like in Sprenkle's (1961) [6] formula given by,

$$V(x, t) = kxN(b_1) - k * cN(b_2)$$

$$b_1 = \frac{\ln(kx/c) + \frac{1}{2}v^2(t * -t)}{v\sqrt{(t * -t)}}$$

$$b_2 = \frac{\ln(kx/c) - \frac{1}{2}v^2(t * -t)}{v\sqrt{(t * -t)}}$$





### Poonam Deshpande and Khursheed Alam

$k$  and  $k^*$  were known parameters and Sprengle (1961) [6] tried to find their values empirically but he was not successful. Also Samuelson (1965) had two unknown parameters  $\alpha$  and  $\beta$  in their formula but even then that was not the correct formulation. Later Samuelson and Merton (1969) understood what was a miss in the earlier valuation and they tried to correct it. Authors [6], mention that their model is based on a concept from Thorp and Kassouf (1967) work. The Authors assumed some ideal conditions while deriving their legendary 'Black-Scholes Model' (see [6]). Authors suggests that if all those conditions are considered meticulously then the value of the option will depend only on the as set price and time and on variables that are taken to be known constants then  $w(x, t)$  is considered to be the option value which is a function of stock price  $x$  and time  $t$ . Then by making substitution for  $\omega(x, t)$  they convert the differential equation into heat diffusion equation and finally substituting back the solution of heat diffusion equation they get the final version of their 'Black-Scholes Model' as,

$$w(x, t) = (x - c) \text{ if } x \geq c \text{ or } 0 \text{ if } x < c$$

Then by making substitution for  $\omega(x, t)$  they convert the differential equation into heat diffusion equation and finally substituting back the solution of heat diffusion equation they get the final version of their 'Black-Scholes Model' as,

$$w(x, t) = xN(d_1) - ce^{r(t-t^*)}N(d_2)$$

$$d_1 = \frac{\ln(x/c) + \frac{1}{2}(r + \frac{1}{2}v^2)(t - t^*)}{v\sqrt{(t - t^*)}}$$

$$d_2 = \frac{\ln(x/c) - \frac{1}{2}(r - \frac{1}{2}v^2)(t - t^*)}{v\sqrt{(t - t^*)}}$$

#### Classification Framework

There are several methods used to solve American option pricing problems. Some common approaches include:

##### Binomial Tree Models

Such as the Cox-Ross-Rubinstein model, where the option pricing problem is discretized over time, and the option values are calculated at each node of the tree.

##### Finite Difference Methods

The finite difference method for American options involves discretizing the option pricing partial differential equation (PDE) in time and space. It's commonly done using explicit, implicit, or Crank-Nicolson schemes.

##### Finite Element Method

##### Monte Carlo Simulation

Involves simulating multiple paths of the underlying asset's price and averaging the payoffs to estimate the option value.

##### Least Squares Monte Carlo (LSMC)

A specific Monte Carlo method where regression is used at each step to estimate the continuation value and optimize the early exercise decision.

##### Integral Equations

Techniques that involve solving integral equations, often applied to American options with dividends.

##### Analytical Approximations

Some methods, like the Barone-Adesi and Whaley approximation, provide closed-form solutions or approximations for American options.

#### PDE Methods

Solving the partial differential equation directly, often using finite difference methods or other numerical techniques. These methods vary in complexity, accuracy, and computational efficiency, and the choice depends on the specific characteristics of the option and the preferences of the analyst or trader. We propose a classification framework based on the underlying principles of numerical methods for American options pricing. The key categories include

##### Finite Difference Methods (FDM)

The key challenge is handling the early exercise feature. For explicit methods, like the explicit finite difference method, stability issues may arise, so implicit or Crank-Nicolson methods are often preferred. Implicit methods



**Poonam Deshpande and Khursheed Alam**

require solving a system of linear equations at each time step, making them computationally more intensive. The key is to incorporate the early exercise feature through the use of boundary conditions that capture the optimal. Types of FDMs are,

1. Explicit Schemes
2. Implicit Schemes
3. Crank-Nicolson Scheme

**Finite Element Methods**

Applying the Finite Element Method (FEM) to price American options involves discretizing the option problem using elements, nodes and basis functions. Here is a simplified overview.

**Discretization**

Divide the spatial domain (stock price, time) into elements. Nodes represent points within these elements.

**Basis Functions**

Define basis functions that approximate the option value within each element. Commonly used functions include piecewise linear or quadratic functions.

**Governing Equation**

Formulate the option pricing problem as a partial differential equation (PDE), considering the early exercise feature for American options.

**Weak Formulation**

Convert the PDE into a weak form using the basis functions. This typically involves integrating the PDE over the elements. Examples of FEM are

Galerkin Method

Petrov-Galerkin Method

**Monte Carlo Methods**

The Monte Carlo method is a computational technique that uses random sampling to obtain numerical results. It can be applied to estimate the value of financial derivatives, including American options. American options are financial contracts that give the holder the right, but not the obligation, to buy (call option) or sell (put option) an underlying asset at a specified price at any time before or at the option's expiration. Following are the examples of Monte Carlo Method.

Least Squares Monte Carlo

Longstaff-Schwartz Method

Here's a basic outline of how the Monte Carlo method can be used to value American options:

1. **Model the Underlying Asset Price Movement** Simulate the future paths of the underlying asset's price. This can be done using stochastic processes like Geometric Brownian Motion (GBM) for the asset price.
2. **Simulate Option Payoff** For each simulated path, calculate the option payoff at each time step. For American options, you need to consider the possibility of early exercise.
3. **Discount Future Payoffs** Discount the future payoffs back to the present using the risk-free rate. This involves calculating the present value of the simulated future payoffs.
4. **Option Value Calculation** Calculate the average of the present values obtained from the simulations. This average provides an estimate of the option value.

**Handle Early Exercise**

For American options, at each time step, compare the calculated option value with the immediate exercise value. If the immediate exercise value is higher, use it as the option value; otherwise, stick with the calculated option value.

**Repeat Simulation**

Repeat the above steps for a sufficient number of simulations to obtain a reliable estimate.

**Binomial Methods**

Binomial methods, such as the Binomial Option Pricing Model (BOPM), are commonly used to value American options. Unlike European options, American options allow the holder to exercise at any time before or at the







### Poonam Deshpande and Khursheed Alam

expiration date. The binomial method provides a discrete-time framework to model the evolution of the underlying asset price and calculate option values at each node of a binomial tree. Examples of Binomial Methods are,

1. Cox-Ross-Rubinstein Model
2. Leisen-Reimer Model

Here's a basic outline of how the binomial method can be applied to value American options:

1. **Build the Binomial Tree**
2. Divide the time to expiration into discrete intervals (time steps).
3. Construct a binomial tree representing possible future prices of the underlying asset. Each node in the tree corresponds to a possible price at a specific point in time.
4. **Calculate Option Payoffs** At each final node of the tree (expiration date), calculate the option payoff based on the difference between the option's strike price and the corresponding underlying asset price.
5. **Backward Induction** Starting from the penultimate time step and moving backward to the present, calculate the option value at each node considering the option holder's decision to either exercise or hold the option.
6. **Early Exercise Decision** At each node, compare the option value with the immediate exercise value (the payoff if the option is exercised immediately). The option holder will exercise the option if the immediate exercise value is higher.
7. **Discount Future Payoffs** Discount the option values back to the present using the risk-free rate.
8. **Repeat for Each Node** Repeat the above steps for each node in the binomial tree until you reach the root of the tree.
9. **Option Value Calculation** The value at the root of the tree represents the estimated present value of the American option.
- 10.

#### Comparative Analysis

The Finite Difference Method (FDM) and Finite Element Method (FEM) are numerical techniques used for solving partial differential equations (PDEs) in various fields, including finance for option pricing. Here's a brief comparison with respect to real-world applicability and adaptability to different option types:

#### Comparison between Finite Difference Method and Finite Element Method

##### Real-world Applicability

##### FDM

Widely used for simple option pricing problems due to its straightforward implementation. It's suitable for standard options with regular geometries and boundary conditions.

##### FEM

More versatile for complex real-world scenarios. FEM excels in handling irregular geometries and varying material properties, making it suitable for a broader range of financial derivatives with intricate payoffs or structures.

#### Adaptability to Different Option Types

##### FDM

Well-suited for standard European and American options. It may face challenges with exotic options or those with complex features, as discretizing irregular payoffs can be cumbersome.

##### FEM

Particularly effective for pricing complex and exotic options. FEM's ability to handle irregular meshes and adapt to non-standard payoffs makes it more suitable for a diverse range of option types, including path-dependent and barrier options. In summary, while FDM is straightforward and effective for standard options, FEM offers greater flexibility and adaptability to handle a wider variety of complex real-world option types. The choice between them depends on the specific characteristics of the option being priced and the computational resources available. These methods vary in complexity, accuracy, and computational efficiency, and the choice depends on the specific characteristics of the option and the preferences of the analyst or trader.

#### Comparison between Front Fixing Method and Fast wavelet based method for pricing American options.

Front-fixing methods and wavelet methods offer distinct approaches to pricing American options:



**Poonam Deshpande and Khursheed Alam****Front-Fixing Method****Approach**

Front-fixing methods, like finite difference or binomial models, discretize the option's time and price space, solving iteratively by stepping through time.

**Strengths**

Computationally efficient, especially for simple payoffs and straightforward structures. Well-suited for regular option contracts.

**Challenges**

May struggle with complex payoffs and discontinuities, and might not capture optimal early exercise decisions accurately.

**Wavelet Method****Approach**

Wavelet methods leverage mathematical techniques that decompose signals into different frequency components. Applied to option pricing, wavelets can capture both smooth and oscillatory behaviour simultaneously.

**Strengths**

Well-suited for addressing discontinuities and capturing irregularities in the underlying asset's price dynamics. Can handle complex payoffs and adapt to non-uniform structures.

**Challenges**

Computational complexity can increase with the level of detail needed, and implementation may require a solid understanding of wavelet theory. In summary, front-fixing methods are efficient but may lack the flexibility to handle complex payoffs and irregularities in the underlying asset's behaviour. Wavelet methods, on the other hand, offer adaptability to discontinuities and intricate structures but may come with increased computational demands. The choice depends on the specific characteristics of the American option being priced and the trade-off between computational efficiency and modeling flexibility.

**How front fixing method is used to price American option**

The front-fixing method is an approach used to price American options by transforming the problem of valuing an American option into a series of European option problems. Here's a simplified explanation of how the front-fixing method works [16]

**Initialization**

Begin by setting up a grid representing the possible values of the underlying asset's price and the time until expiration.

**Iteration**

Start with the final time step and calculate the option value at each node on the grid using the known payoff of the option at expiration.

**Backward Induction**

Move backward in time, step by step, and at each time step, calculate the option value at each node. This involves comparing the intrinsic value of exercising the option immediately with the expected value of continuing to hold the option.

**Early Exercise Decision**

At each node, check if early exercise is optimal by comparing the intrinsic value with the expected future value. If early exercise is optimal, assign the intrinsic value; otherwise, assign the expected future value.

**Continue Iteration**

Repeat the process until you reach the initial time step.

**Final Value**

The calculated value at the initial time step represents the estimated American option price. The "front-fixing" terminology comes from fixing the option's payoff at the front (final time step) and then iteratively solving the problem backward in time. This method simplifies the valuation process by breaking down the American option problem into a series of European option sub-problems, making it computationally more tractable compared to direct methods [14]. However, it may not capture the full complexity of optimal exercise boundaries for certain options with specific features. The transformation of Black F. & Scholes M. equation for AO put under logarithmic





**Poonam Deshpande and Khursheed Alam**

front fixing transformation[11]. The Authors say that the problem of pricing AO can be looked at in two ways first as a free boundary problem and second as a linear complimentary problem but they follow free boundary approach for their method. To take care of the complexity of the free boundary problem Authors decided to transform the PDE of AO into a new nonlinear PDE where a new variable is added to compensate the free boundary. They mention that this technique was originated in physics problem and it is called as *Front Fixing Method* based on *Landau Transform*. After transformation by front fixing method authors used the explicit finite difference scheme for discretization. The Authors say that to avoid the drawbacks of the alternative algebraic approaches they are using the front fixing method along with the explicit finite difference method.

**METHODOLOGY**

Let  $x = [x_1, x_2, x_3, \dots, x_N]^T \in \mathbb{R}^N$  and its supremum norm as

$$\|x\|_\infty = \max\{|x_i| : 1 \leq i \leq N\}$$

**2.1 Fixed Domain Transformation and discretization:**

Company, R. at. el. [4] present the American put option model as the moving free boundary PDE as below,

$$\frac{\partial P}{\partial \tau} = \frac{1}{2} \sigma^2 S^2 \frac{\partial^2 P}{\partial S^2} + rS \frac{\partial P}{\partial S} - rP, \quad S > B(\tau), \quad 0 < \tau \leq T. \tag{1}$$

Together with the initial and boundary conditions

$$\begin{aligned} P(S, 0) &= \max(E - S, 0), \quad S \geq 0 \\ \frac{\partial P}{\partial S}(B(\tau), \tau) &= -1, \\ P(B(\tau), \tau) &= E - B(\tau), \\ \lim_{S \rightarrow \infty} P(S, \tau) &= 0, \\ B(0) &= E \\ P(S, \tau) &= E - S \end{aligned} \tag{2}$$

Here,  $\tau = T - t$  denotes the maturity time,  $S$  is asset price,  $P(S, \tau)$  is the option price,  $B(\tau)$  is the unknown early exercise boundary,  $\sigma$  is the volatility of the asset,  $r$  is the risk free interest rate and  $E$  is the strike price. Company, R. at. el. [11] propose the dimensionless transformation as,

$$p(x, \tau) = \frac{P(S, \tau)}{E}, \quad S_f(\tau) = \frac{B(\tau)}{E}, \quad x = \ln \frac{S}{S_f(\tau)} \tag{3}$$

The above transformation then convert the AO put (1)-(2) to a normalized form

$$\frac{\partial P}{\partial \tau} = \frac{1}{2} \sigma^2 \frac{\partial^2 P}{\partial x^2} + \left( r - \frac{\sigma^2}{2} \right) \frac{\partial P}{\partial x} - rP + \frac{S'_f}{S_f} \frac{\partial P}{\partial x}, \quad x > 0, \quad 0 < \tau \leq T \tag{4}$$

$$p(x, 0) = 0, \quad x \geq 0 \tag{5}$$

$$\frac{\partial P}{\partial x}(0, \tau) = -S'_f(\tau) \tag{6}$$

$$p(0, \tau) = 1 - S_f(\tau) \tag{7}$$

$$\lim_{x \rightarrow \infty} p(x, \tau) = 0 \tag{8}$$

$$S_f(0) = 1 \tag{9}$$

After the transformation (3), they get equation (4) which is a nonlinear differential equation on the domain  $(0, \infty) \times (0, T]$ . But to solve the above transformed equation to solve numerically it has to be defined on the bounded domain therefore authors introduce  $x_{max}$ , which is large so the  $p(x_{max}, \tau) = 0$  and in turn equations (4)-(9) can now be studied on the fixed domain  $(0, x_{max}) \times (0, T]$ . Then they introduce the computational grid of  $M + 1$  space points,  $N$  time points and  $h$   $k$  are step sizes respectively.





**Poonam Deshpande and Khursheed Alam**

$$\begin{aligned} h &= \frac{x_{max}}{M+1}, & k &= \frac{T}{N} \\ x_j &= h_j, & j &= 0, \dots, M+1 \\ \tau^n &= kn, & n &= 0, \dots, N \end{aligned} \tag{10}$$

They introduce  $P_j^n = p(x_j, \tau^n)$

$$\begin{aligned} \frac{P_j^{n+1} - P_j^n}{k} &= \frac{1}{2} \sigma^2 \frac{P_{j-1}^n - 2P_j^n + P_{j+1}^n}{h^2} - \left(r - \frac{\sigma^2}{2}\right) \frac{P_{j+1}^n - P_{j-1}^n}{2h} \\ &+ \left(\frac{S_j^{n+1} - S_j^n}{kS_j^n}\right) \left(\frac{P_{j+1}^n - P_{j-1}^n}{2h}\right) - rP_j^n \end{aligned} \tag{11}$$

$1 \leq j \leq M, \quad 0 \leq n \leq N-1$

Authors denote  $\mu = k/h^2$  and then the equation (11) transforms to,

$$P_j^{n+1} = aP_{j-1}^n + bP_j^n + cP_{j+1}^n + \frac{S_j^{n+1} - S_j^n}{2hS_j^n} (P_{j+1}^n - P_{j-1}^n) \tag{12}$$

$$a = \frac{\mu}{2} \left(\sigma^2 - \left(r - \frac{\sigma^2}{2}\right)h\right), \quad b = 1 - \sigma^2\mu - rk, \quad c = \frac{\mu}{2} \left(\sigma^2 + \left(r - \frac{\sigma^2}{2}\right)h\right) \tag{13}$$

This leads to the following algorithmic form.

$$S_f^{n+1} = d^n S_f^n, \quad d^n = \frac{\alpha - (aP_0^n + bP_1^n + cP_2^n - (P_2^n - P_0^n)/2h)}{(P_2^n - P_0^n)/2h + \beta S_f^n} \tag{14}$$

$$P_0^{n+1} = 1 - S_f^{n+1} \tag{15}$$

$$P_1^{n+1} = \alpha - \beta S_f^{n+1} \tag{16}$$

$$P_j^{n+1} = a^{-n} P_{j-1}^n + bP_j^n + c^{-n} P_{j+1}^n \tag{17}$$

Where,

$$a^{-n} = a - \frac{S_f^{n+1} - S_f^n}{2hS_f^n}, \quad c^{-n} = c + \frac{S_f^{n+1} - S_f^n}{2hS_f^n}, \quad P_{M+1}^{n+1} = 0 \tag{18}$$

With initial conditions,

$$S_f^0 = 1, \quad P_j^0 = 0, \quad 0 \leq j \leq M+1 \tag{19}$$

**How Fast Wavelets Method is used to price American Options**

The idea of wavelets came into existence 3 decades ago. If the solution of a partial differential equation can be converted to a linear combination of so-called basis functions, then this can be used to solve the Partial differential equations. More over these basis functions can be trigonometric [2]. This method is more stable than other methods like finite difference methods. To consider this wavelet method several facts were taken into consideration. Siddiqi et al. states that even though the option pricing is a new concept its founding fathers fetched a Nobel Prize in 1997. It was received by only Merton R.C. and Scholes M. as Black F. passed away in 1995. They mentioned that the concept of option pricing is ancient. Merton had a direct effect on the black –Scholes Model and he generalized the idea to areas outside financial markets [2]Option pricing became popular because of numerical methods used by Wilmott, Dewynne, Howison and Wilmott, Howison, Dewyonne. The computational methods as the tool from mathematics was emphasized by Merton and they became the integral part of option pricing as numerical methods give insight into valuation and visualization of European and American options [2].Rigorous work done by various scientists in this area where they used methods like SSORP-PCG, SORP etc. other methods include Laplace transform method and finite element method. The object of this paper is to explore the wavelet based methods for European options where they will be discussing the wavelet method for linear and non-linear heat equation [2]. Following is the model for valuating European/American call option

$$\frac{\partial c}{\partial t} + \frac{1}{2} \sigma^2 S^2 \frac{\partial^2 C}{\partial S^2} + rS \frac{\partial C}{\partial S} - rC = 0$$

$$C(S, T) = \max(S - E, 0)$$

$$C(0, t) = 0$$

$$C(S, t) \rightarrow S \text{ as } S \rightarrow \infty$$

Where S = asset price, E = Strike price, T = maturity time,  $\sigma$ = Standard deviation & r = Rate of interest. Similarly, the model for European Put option is given by





**Poonam Deshpande and Khursheed Alam**

$$\frac{\partial P}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 P}{\partial S^2} + rS \frac{\partial P}{\partial S} - rP = 0$$

$$P(s, t) = (E - S, 0)$$

$$P(0, t) = Ee^{-r(T-t)} \text{ if } r \text{ is independent of time}$$

$$P(0, t) = Ee^{-\int_t^T r(\tau) d\tau} \text{ if } r \text{ is dependent of time}$$

as  $S \rightarrow \infty$ , the option is unlikely to be exercised and so

$$P(S, t) \rightarrow 0 \text{ as } S \rightarrow \infty$$

The above models can be transformed into the linear diffusion equation and the discretization of the same can be given as,

$$u_j^n \cong u(x_j, t_n), \quad t_n = n\Delta t$$

$$u^{n+1} = Au^n \cdot x_j = (\Delta x_j \dots \dots N_{xd})$$

$$u^0 = u_o, \quad u \in R$$

The solution of the above is given by,  $u^n = A^n U_0$

Following is the algorithm to find the solution of the discretized equations,

$$B = SAS^{-1}$$

$$C = I \quad \text{Next two steps are iterated } m \text{ times,}$$

$$C = TRUNC(C + BC, \epsilon)$$

$$B = TRUNC(BB, \epsilon)$$

$$u^n = S^{-1}(B S u^0)$$

The matrix S is nothing but Fast Wavelet Transform. Siddiqi et al. then discusses the outline of the wavelet-based solution of the linear diffusion equation. The final product of that discussion is the *Fast Wavelet Transform* of an interval  $2^{-n}$ .

$$S_k^0 = 2^{\frac{n}{2}} \int_{2^{-n(k-1)}}^{2^{-nk}} f(x) dx, \quad k = 1, 2, \dots, N$$

Using discretization, they get the Lax-Wendroff type model as,

$$u_n(t + \Delta t) \cong u_n(t) - tA_n u_n(t) + 0.5(\Delta^2 t A_n^2 u_n(t))$$

$$u_n^0 = u_{0n}$$

$$u_n^{k+1} = u_n^k - tA_n u_n^k + 0.5\Delta^2 t A_n^2 u_n^k$$

Wavelet based Numerical Solution of General Black-Scholes Model incorporating Feedback effects given below.

Wavelet based Numerical Solution of General Black-Scholes Model incorporating Feedback effects given below.





**Poonam Deshpande and Khursheed Alam**

$$\frac{\partial c}{\partial t} + \frac{1}{2} \left[ \frac{[1 - \rho \frac{\partial c}{\partial x}]^2}{1 - \rho \frac{\partial c}{\partial x} - \rho x \frac{\partial^2 c}{\partial x^2}} \right] a^2 x^2 \frac{\partial^2 c}{\partial x^2} + r \left( x \frac{\partial c}{\partial x} - c \right) = 0, \quad t < T - \epsilon$$

$$c(x, T - \epsilon) = C_{BS}(x, T - \epsilon)$$

$$c(0, t) = 0$$

$$|c(x, t) - (x - Ke^{-r(T-t)})| = 0$$

$$c(x, t) = C_{BS}(x, t) \text{ for } T - \epsilon \leq t \leq T$$

$$C_{BS}(x, t) = xN(d_1) - Ke^{-r(T-t)}N(d_2)$$

$$d_1 = \frac{\log \log \left( \frac{x}{K} \right) + \left( r + \frac{1}{2} \sigma^2 \right) (T - t)}{\sigma \sqrt{T - t}}$$

$$d_2 = d_1 - \sigma \sqrt{T - t}$$

$$N(z) = \frac{1}{\sigma} \int_{-\infty}^z e^{-\frac{s^2}{2}} ds$$

All the conventional numerical methods for finding the solution to option pricing model can be categorized into three, such as finite difference method, finite element method and spectral method but wavelet-based methods are novel and it allows the solution in terms of basis functions called wavelets [2]. Also that these methods give advantages of all the three classical methods. Then with the brief explanation of the method they come to the result that the derivative of the approximate function can be given by,

$$f^{J(m)}(x) = \sum_{i \in Z_{\Omega}^J} f_i^{(m)}(x) f_{j,i}$$

For the nonlinear partial differential equation, they use traditional collocation approach and get,

$$u_i^{J(m)}(t) = \sum_{k \in Z_{\Omega}^J} U_{i,k}^{(m)} u_{j,k}(t)$$

$$U_{i,k}^{(m)} = \sum_{j=0}^J \sum_{p \in Z_{\Omega}^J} \psi_p^{J(m)}(x_{j,i}) D_{e,k}^{i,j}$$

The final solution is given by,

$$u_j(s, t) = \sum_{i \in Z_{\Omega}^J} I_i(x) u_i^J(t)$$

$$I_i(x) = \sum_{j=0}^J \sum_{k \in Z_{\Omega}^J} D_{e,k}^{i,j} \psi_{i,k}(x)$$

Above method is better method of finding the solution of the option pricing model is superior to the three traditional methods as it combines the best properties of all the methods in one and using *Fast Wavelet Method*. Authors claimed that their method is faster. With the technological advancement more such methods will be developed which will be much sophisticated[2].

**Challenges and Future Directions**

Numerical methods for pricing American options face several challenges [29]

**Early Exercise Decision**

Unlike European options, American options can be exercised at any time before expiration. Determining the optimal exercise strategy adds complexity to the numerical methods.

**Discontinuity in Payoffs**

American options exhibit discontinuous payoffs due to potential early exercise. This makes it challenging to model accurately and requires careful consideration in numerical schemes.

**High Dimensionality**

For multi-dimensional or path-dependent options, the computational burden increases significantly, making numerical solutions computationally expensive and time-consuming.





**Poonam Deshpande and Khursheed Alam****Stability and Convergence**

Numerical methods need to ensure stability and convergence to obtain accurate results. Some methods may struggle to maintain stability, especially with irregular payoffs or complex financial instruments.

**Grid Dependency**

Many numerical techniques involve discretizing the option's underlying state space. The choice of grid size and spacing can impact the accuracy of the results, and finding an optimal balance is non-trivial.

**Computational Cost**

American option pricing often involves solving partial differential equations or dynamic programming problems. The computational cost can be high, especially when dealing with a large number of time steps or complex option structures. Addressing these challenges requires a careful selection of numerical methods, considering the specific characteristics of the American option being priced and the available computational resources.

**CONCLUSIONS**

Finite Difference Method is simpler to implement but may require fine grids for accuracy, impacting computational efficiency. Finite Element Method offers higher accuracy and adaptability to complex geometries but demands more computational resources. In summary, the choice between Finite Difference and Finite Element methods depends on the specific characteristics of the problem at hand. For problems with simple geometries and where computational efficiency is crucial; Finite Difference Method may be preferable. In contrast, Finite Element Method is a strong candidate for accurate solutions in problems involving irregular geometries and where higher accuracy is paramount, even at the cost of increased computational demands. These methods vary in complexity, accuracy, and computational efficiency, and the choice depends on the specific characteristics of the option and the preferences of the analyst or trader.

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**Poonam Deshpande and Khursheed Alam**

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**Comparison between Finite Difference Method and Finite Element Method**

Name of the method	Stability	Efficiency	Computational Efficiency
Finite Difference Method	Generally, stable for well-behaved problems, but stability can be an issue for certain discretization schemes. The explicit schemes may have	Accuracy depends on the chosen discretization scheme. Second - order accuracy is achievable with central differencing, but higher-order accuracy may require more	Generally, computationally efficient for simple geometries and regular grids. Explicit schemes can be





**Poonam Deshpande and Khursheed Alam**

	<p>stability restrictions, requiring small time steps for convergence. Implicit schemes tend to be unconditionally stable but may involve solving large systems of equations.</p>	<p>complex stencils. Sensitive to irregular geometries and complex boundary conditions</p>	<p>parallelized effectively but may require small time steps. Implicit schemes involve solving linear systems, which may be computationally expensive for large systems.</p>
<p>Finite Element Method</p>	<p>Inherently stable due to the variational formulation, which often results in well-conditioned systems of equations. The stability is influenced by the choice of basis functions and mesh refinement.</p>	<p>Can achieve higher accuracy, especially when using higher-order basis functions and refined meshes. Provides flexibility in handling irregular geometries and complex boundary conditions through proper mesh generation.</p>	<p>More computationally intensive due to the need for solving systems of equations arising from the variational formulation. Well-suited for parallel computing, particularly for solving large-scale problems. Efficient for problems with irregular geometries and adaptability to unstructured meshes.</p>





## Wavelet-Based Diffusion Model for Image Denoising and Deblurring

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### ABSTRACT

In this paper, a smooth time-dependent model is presented for deblurring and Gaussian noise reduction during the image reconstruction process. For the aim of smoothing, discrete wavelet transform is applied to a non-linear diffusion model. Numerical discretization of the suggested model is accomplished using the finite difference method. The Well-Posedness of the model is presented in terms of experimental analysis. ISNR and SSIM metrics are used to evaluate the denoised image's visual quality.

**Keywords:** Image denoising, Anisotropic diffusion, Wavelet transform,

## INTRODUCTION

The visual quality of an image is crucial for computer vision. The image is tainted by noise and blur, which lowers the image's visual quality. The many methods of image deblurring have been the subject of extensive research. There are many different types of noise, including Poisson, Gaussian, and speckle noise. During the acquisition and transmission of the image, the original signal and noisy signal are added or multiplied to create the degraded signal. Images are often deblurred and denoised using partial differential equations (PDEs) based methods. The image is altered concerning time in PDE-based approaches by Witkin 1983. The image features are eventually improved or made simpler as a result of the progression. Perona and Malik (1990) have introduced an anisotropic diffusion, in terms of a cutting-edge approach for removing noise from images while preserving edge and fine detail. Rudin et al. (1992) investigate a non-linear total variation algorithm for edge detection. For a long time, computer vision researchers have been interested in deblurring difficulties, and numerous articles on this and related topics exist. Marquina and Osher (2000) examined total variational technique non-blind deconvolution. Chan and Wong (1998) investigated blind deconvolution. Liu et al. (2010) presented the split Bregman method for image deblurring. Welk et al. (2005) proposed a total variational-based model for image deblurring with space invariant kernel. Wavelet-based





**Alka Chauhan and Santosh Kumar**

time-dependent model for image denoising is presented by Kumar et al. (2018). Mallat et al. (1989) presented the orthogonal multiresolution approach in terms of wavelet orthonormal bases for signal processing. The structure of wavelet bases enables an efficient computational method and reveals the signal regularity through the coefficient amplitude. Wavelets are strongly localized, though, and only a few of coefficients are required to represent nearby transitory structures. A sparse representation of piecewise regular signals which may also contain transients and singularities is defined as a wavelet basis. Large wavelet coefficients are found close to edges and erratic textures in images. The wavelet-based anisotropic diffusion model is presented by Kumar et al. (2018) to improve the visual quality of the denoised image at a fast convergence rate. We presented a wavelet-based anisotropic diffusion model in this work for deblurring and denoising. Below is the structure of this paper: An overview of wavelet transforms is provided in Section 2. Section 3 presents the image-denoising algorithm. The discretized scheme of the proposed model is given in section 4. Section 5 presents the experimental analysis and Section 6 concludes with a conclusion.

**Wavelets transform**

The wavelet transform is a technique that divides information into several frequency components and then analyzes each component with a resolution according to its scale. Small waves that are very well localized in both the temporal and frequency domains are called wavelets. The wavelet transform which can be obtained by translating and distorting the mother wavelet is the breakdown of a signal into orthonormal wavelet bases. The translation and scale parameters are two variables that determine the transformed signal. The mother wavelet is the transforming function denoted by  $\psi(y)$ . The mother wavelet with  $l \in \mathbb{N}$  vanishing moments can be defined as

$\int_{-\infty}^{\infty} y^k \psi(y) dy = 0$ , where  $k \in (0, 1, 2, \dots, l)$  and  $y \in \mathbb{R}$ . The function  $\psi(y)$  and its all derivatives up to order  $k$  belongs to  $L^{\infty} \in \mathbb{R}$ . The wavelet basis or orthonormal basis can be constructed from the mother wavelet function and defined as

$\psi_{j,k}(y) = 2^{\frac{j}{2}} \psi(2^j y - k)$ , where  $j, k \in \mathbb{Z}$ . The major wavelets are Daubechies Wavelet, Coiflets Wavelet, Biorthogonal Wavelet, Symlets Wavelet, Morlet Wavelet, and Meyer Wavelet. These wavelets are used to transform the signals from one domain to another domain. [5], [3] presented a discrete wavelet transform for a two-dimensional signal or an image decomposition and reconstruction. A filter bank that contained wavelet high pass filter  $A$  and scaling low pass filter  $B$  is explained for this purpose with  $a_k$  and  $b_k$  filter coefficients, respectively. The wavelet coefficients of a signal  $f(y)$  can be easily computed via

$$C_{m,n} = \int_{-\infty}^{\infty} f(y) \psi_{m,n}(y) dy$$

and to recover  $f(y)$  from the wavelet coefficient the synthesis formula is used and it is defined as:

$$f(y) = \sum_{m,n} C_{m,n} \psi_{m,n}(y)$$

consider a scaling function  $\phi(y) \in L^2(\mathbb{R})$  which is equally spaced at  $2^j$  time points where  $j \in \mathbb{Z}$  and scaling function is related with wavelet basis function as:  $\psi(y) = \sqrt{2} \sum_k a_k \phi(y - 2k)$

and scaling function is defined as:

$$\phi(y) = \sqrt{2} \sum_k b_k \phi(y - 2k)$$

$a_k$  and  $b_k$  filter coefficients play a very curical role in given discrete wavelet transform. DWT can be represented in terms of filter coefficient for a given series as:

$$C_{j+1,n} = \sum_k C_{j,k} b_k(k - 2n)$$

$$d_{j+1,n} = \sum_k C_{j,k} a_k(k - 2n)$$

Thus above equation provides a recursive algorithm for wavelet decomposition through  $a_k$  and  $b_k$ . Similarly we can find a recursive relation for function synthesis based on its wavelet coefficient  $d_{j,n}$  and  $C_{j,n}$

$$C_{j,k} = \sum_k C_{j+1,n} b_k(k - 2n) + \sum_k d_{j+1,n} a_k(k - 2n)$$

The reconstruction can then be achieved by iterating this process and climbing the resolution levels back to the original data. The 2D wavelet basis function can be defined in terms of two 1D wavelet basis function along the horizontal and vertical directions. The corresponding 2D filter coefficient can be defined as:

$$b_{LL}(k, l) = b(k)b(l), \quad b_{LH}(k, l) = b(k)a(l)$$

$$b_{HL}(k, l) = a(k)b(l), \quad b_{HH}(k, l) = a(k)a(l)$$





**Alka Chauhan and Santosh Kumar**

Where L, H denotes the low pass and high pass filtering characteristic in horizontal and vertical direction respectively.

**Wavelet-Based Denoising Technique**

Let  $u_0(x, y)$  is denoted the noisy image and  $u(x, y)$  is used to present the desired clean image. The Gaussian additive white noise is presented as  $n(x, y)$ , this noise is uniformly distributed over the image and  $k$  is the Gaussian blur kernel. Mathematically it can be written as:

$$u_0(x, y) = (k * u)(x, y) + n(x, y) \tag{3.1}$$

In order for deblurring and denoising the image the optimal energy functional is taken by Welk et al. which is defined as:

$$E(u) = \int_{\Omega} \phi(|\nabla u|^2) dx dy + \frac{\lambda}{2} \int_{\Omega} (k * u - u_0)^2 dx dy. \tag{3.2}$$

where the first integral presented smoothness term and second integral form is presented data form. After applying the Euler-Lagrange equation the equation (3.2) becomes:

$$0 = \text{div}(\phi'(|\nabla u|^2))(\nabla u) + \lambda k * (k * u - u_0) \tag{3.3}$$

Welk et al. anisotropic diffusion model for deblurring and denoising is achieved after applying gradient descent method on equation (3.3)

$$\frac{\partial u}{\partial t} = \text{div}(C(|\nabla u|^2))(\nabla u) + \lambda k * (k * u - u_0) \tag{3.4}$$

Here the diffusivity  $C(s^2) = \phi'(s^2)$  is related to the regulariser in the energy functional with homogenous Neumann boundary condition which is same in [7]. Proposed wavelet based model is:

$$\frac{\partial u}{\partial t} = \text{div}(C(|\nabla W u|^2))(\nabla W u) + \lambda k * (W(k * u) - u_0) \tag{3.5}$$

$Wu$  is an abbreviation for wavelet coefficients. Wavelet decomposition and reconstruction is used to remove noise caused by preceding smoothness,  $X = \text{wavedec2}(u, 'sym4', 1)$ , where 'sym4' is a wavelet filter, performs the decomposition operation. The wavelet coefficient is rebuilt using Matlab  $Wu = \text{wrccoef2}(X, 'sym4', 1)$  function.

**Discrete scheme**

We still write,  $Wu$  as  $u$ . Let  $u_{ij}^n$  be the approximation to the value  $u(x_i, y_j, t_n)$ , where

$$x_i = i \Delta x, \quad y_j = j \Delta y, \quad i, j = 1, 2, \dots, N,$$

$$N \Delta x = 1, \quad t_n = n \Delta t, \quad n \geq 1,$$

where  $\Delta x, \Delta y$  and  $\Delta t$  are the spatial step sizes and the time step size respectively.

The explicit partial derivatives of models (2.6) can be expressed as:

$$u_{ij}^t = \frac{1}{2\Delta x} \left( (c_{i+1,j}^n + c_{i,j}^n)(u_{i+1,j}^n - u_{i,j}^n) - (c_{i,j}^n + c_{i-1,j}^n)(u_{i,j}^n - u_{i-1,j}^n) \right) + \frac{1}{2\Delta x} \left( (c_{i,j+1}^n + c_{i,j}^n)(u_{i,j+1}^n - u_{i,j}^n) - (c_{i,j}^n + c_{i,j-1}^n)(u_{i,j}^n - u_{i,j-1}^n) \right) - \lambda k * (k * u - u_0),$$

where the diffusivity  $c(|\nabla u|)$  is discretized by,

$$c_{ij}^n = \phi \left( \left( \frac{u_{i+1,j}^n - u_{i-1,j}^n}{\Delta x} \right)^2 + \left( \frac{u_{i,j+1}^n - u_{i,j-1}^n}{\Delta x} \right)^2 \right),$$

with homogeneous Neumann boundary conditions. The explicit method is stable and convergent for  $\frac{\Delta x}{\Delta t} < 0.5$ , see [8].

**Numerical experiments**

We utilize grayscale images like the Lena and Boat images to run the numerical experiments. The initial pixel values of both images are in the range [0, 255]. We use Matlab standard `imnoise` function to introduce Gaussian white noise. Image intensities are adjusted from zero to one for the numerical experiments. Our Lagrange multiplier is  $\lambda = 0.85$ , which is the same as the one employed by (Chan et al. 1999) and (Chang and Chern, 2003). The effectiveness of noise has an impact on our filtering outcomes. This number of iterations has an impact on the restoration outcome as well. If  $N$  were greater than the number of steps needed to achieve the optimal denoising, the image would deteriorate further. For evaluating the quality of image denoising, we employ Improved signal to noise ratio (ISNR) and







**Alka Chauhan and Santosh Kumar**

Similarity structure index(SSIM) is built in Mat lab. Improvement in the signal quality (ISNR) is used to measure the goodness of the restored image: and it can be defined as

$$ISNR = 10 \log_{10} \left( \frac{\sum_{ij} |u_{ij} - (u_0)_{ij}|^2}{\sum_{ij} |u_{ij} - (u_{new})_{ij}|^2} \right) \text{dB},$$

**CONCLUSION**

In this study, we presented a smooth diffusion model for image deblurring and denoising. The discrete wavelet transform is applied for priori smoothing. With the help of finite difference method, the suggested model is discretized. In comparison to the earlier model, the suggested numerical discretization approach converges ten times faster. The experimental results demonstrate that proposed model achieved higher ISNR and SSIM values with better visual quality for the denoised and deblurred image.

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**Table 1: Quantitative analysis using SSIM and PSNR as metrics.:**

Noise variance		0.002		0.004		0.006
Lena image	ISNR	SSIM	ISNR	SSIM	ISNR	SSIM
old model	1.8559	0.6866	2.2944	0.5730	2.4794	0.4950
Proposed model	2.1184	0.6984	2.9270	0.6316	3.4305	0.5762
Boat image	ISNR	SSIM	ISNR	SSIM	ISNR	SSIM
old model	1.8367	0.6337	2.2619	0.5317	2.3946	0.4524
Proposed model	2.0775	0.6484	2.8141	0.5836	3.3552	0.5365





Alka Chauhan and Santosh Kumar



Figure 1: (a-b) Left side original Boat image and right side original Lena image.



Figure 2: (a-c) Represented blur and noisy images with different level of Gaussian noise ( $\sigma^2 = 0.002,0.004,0.006,$ ) respectively)



Figure 2: (d-f) present denoised image by old model at 500 iterations (3.5),

Figure 2: (g-i) present denoised image by our model at 50 iterations.

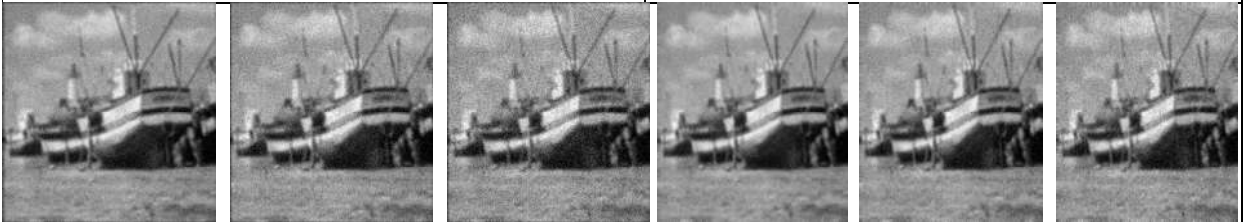


Figure 3: (a-c) represented blur and noisy images with different level of Gaussian noise ( $\sigma^2 = 0.002,0.004,0.006,$ ) respectively);

Figure 3: (d-f) present denoised image by old model at 500 iterations (3.5),



Figure 3: (g-i) present denoised image by our model at 50 iterations.





## Algorithmic Solutions for Hate Speech Detection: A Machine Learning Perspective

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### ABSTRACT

The prevalence of hate speech in digital spaces raises concerns about online safety and community well-being, so the need to build effective and scalable detection systems becomes critical. This research paper digs into "Algorithmic Solutions for Hate Speech Detection: A Machine Learning Perspective," intending to explore the use of multiple algorithms based on machine learning for detecting and mitigating hate speech in online platforms. This study evaluates the performance of several machine learning models, including natural language processing and deep learning techniques, using a large dataset handpicked for training and evaluation. We examine the merits and limits of each method in the context of hate speech identification using thorough feature engineering and stringent assessment measures. Furthermore, the article tackles the ethical implications of using automated content moderation systems. Examining concerns such as prejudice, fairness, and free speech, we explore the complex world of ethical AI practices in search of algorithmic solutions to combat hate speech.

**Keywords:** Ethical Considerations, Content Moderation, Online Security, Freedom of Expression, Natural Language Processing, Text Mining.

### INTRODUCTION

The widespread use of digital communication platforms has substantially altered the mechanics of information sharing, opening up hitherto unimagined prospects for worldwide connectivity. However, the expansion of hate speech in online places is a major worry due to this digital transformation. Hate speech, which is defined as





Salim Al Hudafi et al.,

utterances that promote violence, prejudice, or hate toward specific persons or groups, poses a significant risk to the well-being and safety of online communities. In response to the growing threat of hate speech, there is a growing realization of the necessity for effective and scalable detection techniques. This research article, titled "Algorithmic Solutions for Hate Speech Detection: A Machine Learning Perspective," dives into the confluence of machine learning and content moderation, intending to investigate the usefulness of various algorithms in recognizing and reducing hate speech. The major goal of this research is to examine the performance of several machine learning models, which include both standard natural language processing techniques and more advanced deep learning approaches. Our research seeks to give a comprehensive knowledge of the strengths and limits associated with each algorithm by employing a properly curated dataset, therefore contributing to the improvement of hate speech identification approaches. This study critically interacts with the ethical problems inherent in the deployment of algorithmic methods for content filtering, in addition to the technological elements. The discussion revolves around issues of prejudice, justice, and the difficult balance between limiting damaging content and safeguarding free speech. As we investigate algorithmic frameworks for hate speech identification, we must negotiate this complex environment of ethical issues and obligations, ensuring that our technology achievements are consistent with equality and inclusion ideals.

## MATERIAL AND METHODS

### Dataset

#### Data Collection

Collected a diversified dataset encompassing examples of hate speech and non-hate speech from numerous internet sites.

**Annotation** Manually tagged the dataset to guarantee correct training and assessment.

#### Data Preprocessing

**Text Cleaning** Removed unnecessary characters, symbols, and formatting irregularities from the textual material.

**Tokenization** Separated the text into discrete tokens to aid further analysis.

**Normalization** is the process of standardizing text to a uniform format to assure consistency.

Extraction of Features

**Embeddings of words** To capture semantic links between words, pre-trained word embeddings (e.g., Word2Vec, GloVe) were used.

**Sentiment Analysis** Sentiment scores were used to determine the emotional tone of the text.

**Contextual Information** Investigated contextual aspects while taking into account the surrounding material to have a thorough comprehension.

Models of machine learning

**Model Choosing** Support Vector Machines (SVM), Naive Bayes, and deep learning models including recurrent neural networks (RNN) and transformer-based models (e.g., BERT) were used.

**Training** We trained each model on the labeled dataset to learn hate speech patterns.

### Evaluation Metrics

#### Cross-Validation

Cross-validation techniques were used to guarantee the models' resilience.

**Performance Metrics** The models were evaluated using precision-recall, F1 score, and accuracy to determine their capacity to properly identify hate speech incidents.

### Ethical Considerations

**Bias study** Conducted a study to detect and minimize biases in the dataset and algorithms, addressing concerns about fairness.

**openness** Ensured openness in the model decision-making process by offering detailed explanations for content moderation.

### Implementation

**Programming Languages** Python was used to implement the algorithms, and machine learning libraries like sci-kit-learn, TensorFlow, and PyTorch were utilized.





Salim Al Hudafi et al.,

**Scalability** regarded as the ability to handle big datasets, process information in real-time, and optimize algorithms for effectiveness.

#### **Validation**

**Validation Set** A portion of the dataset was set aside for validation, to see how well the models generalize to new, previously unseen data.

**Comparative Analysis** Compare the performance of various machine learning models to identify the most effective solution for hate speech detection.

#### **iterative refinement**

**Fine-tuning** Based on evaluation results, the models were iteratively refined, with hyperparameters adjusted and algorithms improved to improve detection accuracy.

## RESULT AND DISCUSSION

Analyzing many machine learning techniques to detect hate speech produced some interesting results. The models underwent thorough evaluation through the use of precision, recall, F1 score, and accuracy as performance indicators. They were trained on a broad dataset that included examples of both hate speech and non-hate speech.

#### **Model Performance**

Naive Bayes and SVM Conventional algorithms like Naive Bayes and Support Vector Machines (SVM) performed admirably, especially in situations where the features were well-defined.

Deep Learning Models: State-of-the-art models that captured intricate contextual links in the text included recurrent neural networks (RNN) and transformer-based architectures (BERT). These models performed better than others.

#### **Ethics-Related Considerations**

**Bias Mitigation:** The study examined possible biases in the dataset and algorithms, recognizing that fair content moderation depends on reducing biases.

#### **Decision-Making Process Transparency**

Upholding this principle was essential to fostering user confidence and elucidating the reasoning behind content filtering measures.

#### **Algorithmic Effectiveness**

Deep learning models' skills in capturing nuanced contextual information made them very successful at detecting hate speech in dynamic online contexts.

#### **Interpretable Models**

To provide a clear grasp of the moderation process, it was important to strike a balance between the interpretability and the complexity of deep learning models.

## CONCLUSION

This work adds to the current conversation on algorithmic approaches to hate speech identification with its findings and debates. Despite the impressive capabilities of deep learning models, responsible and efficient content moderation systems must take into account ethical issues, interpretability, and practicality. The results highlight the necessity of a comprehensive strategy that strikes a balance between algorithmic aptitude and moral concerns in order to promote safer and more welcoming digital environments. Maintaining a current understanding of the ever-changing landscape of hate speech detection requires ongoing study and improvement.

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## Remote Sensing Applications for Human Healthcare: A Review

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### ABSTRACT

Medical science is benefiting from the fastest-growing Remote Sensing (RS) technology that is becoming an integral part of public health, safety, and research initiatives. The study presents review of RS technology in radiological, physiological, epidemiological and environmental approach for better healthcare services and tracking the spread of infectious diseases, and others health related issues. Many health care investigations using RS tools were explored in the present study for analyzing environmental factors, control of endemic diseases, service delivery, and human transmission risks. Modified RS applications with latest technology in real-time would flourish the standard services of healthcare sectors by connecting people during emergency medical services. This study will provide an overview of the existing fields that carry great promise in developing policies and providing best public healthcare services towards sustainable development.

**Keywords:** Remote Sensing; Health-care; Safety; Services.





## INTRODUCTION

Remote Sensing (RS) is a part of electromagnetic spectrum of specific wavelength range in x-ray, ultraviolet, infrared, visible, thermal, microwave that detect objects without any contact. RS images captured by a sensor from a distance detect and record reflected or emitted energy. Landsat-1 was the first EO (Earth Observing) satellite launched 4 decades ago (23<sup>rd</sup> July 1972) by NASA from Vandenberg Air force Base in California. It acquired 75% of the Earth's surface during its time span of 6 years that can be visualized more efficiently. One of the captured imagery of Landsat-1 observing huge mass of fire (327.8 sq.km) in an isolated part of central Alaska and a bird view of full damage at once were able to see for the first time ever, while it was still burning. This type of larger view of earth surface holds a great promise in the prevention and very early detection of pathological symptoms. Most of the public healthcare research were adopted using the sensors of Landsat-MSS & TM, NOAA, AVHRR, SPOT and others. These sensors data were the best extraction of water bodies, landscape structure, and vegetation cover that play vital role in exploring human-vector contact and its surrounding environmental factors. Climate change, erosion of soil types, degradation of natural resources, environmental pollution were few factors that contributes for the spread of many diseases. Floods, landslides, tsunamis, earthquakes, hurricanes are the categories of natural hazards that may result in intensifying certain diseases; whereas global warming, melting of ice have led in rising new disease outbreaks. Prevailing temperature, precipitation, wind speed & its direction, humidity are the environmental variables that influences the most activity of pathogens and ultimately impacting humans. These interactions, healthcare concerns and long periods of pathological patterns could be monitored effectively from specific satellite data. RS serves as fundamental data for location based services, health trend analysis, tracking spread of infectious diseases, visualizing hospitals, healthcare information and many more. Forecasting the outbreaks of diseases and its environmental factors could be analyzed efficiently through high-spatial resolution of a satellite sensor by focusing on their ecology. Applying basic working principles of sensors through electrical signals are the most accurate and efficiently in the present era in human health monitoring [12]. Non-invasive wearable remote sensors, actuators as a modern communication techniques propose a low-cost and logical solutions allowing the elderly people to live at their resident comfortably rather than costly medical facilities [21]. RS is the advanced technology that gained rapid interest during Covid-19 for contactless inspections and vital signs.

## RESULTS AND ANALYSIS

### Rs for Radiological Applications

#### RS Medical Instruments

Medical radiography visualizes the internal parts of the human body using x-ray to assess diseases, foreign objects, and structural damages through a beam of projected rays[13]. The detectors record the object based on the density and structural composition of the targeted object. Mammography is a specialized medical imaging technique that produces a low-dose x-ray beam to look into the initial diagnosis and early detection of breast diseases, typically through detection of characteristics masses or micro-calcifications[16]. It uses a small dose of ionizing radiation to produce images for medical examination of cancer before women experience its symptoms. General screening mammograms reduce the number of deaths from breast diseases between the ages of 40 to 74 [16]. Tomography records the deep internal structures within the body through x-rays lying in a plane of coincidence. These are more appreciated in studying kidneys, the brain, abdominal structures, tissue occurring diseases, and injuries in the internal body. Multidirectional tomo graphic techniques are the most widely used instrument to produce even more precise and sharper images while moving in a circular or elliptical manner [27]. Tomo graphic processes have also been employed in examining smaller bones and various ear structures since these are surrounded by relatively dense temporal bone [27].



Manjunatha *et al.*,

## RS FOR PHYSIOLOGICAL APPLICATIONS

### Sensors for monitoring Automatic Nervous System (ANS)

A microwave radar of 24 GHz was used in a remote measuring experiment of the Heart Rate Variability (HRV) induced by a stressful sound and food while driving or operating equipment[15,37]. Suzuki [37] conducted an experiment consisted of a prototype microwave Doppler radar device of a compact 24 GHz (8 × 5 × 3 cm) installed behind the chair of eight volunteers. Low-Frequency/ High-Frequency (LF/HF) units of the HRV were measured by a prototype system using Maximum Entropy Method (MEM) [37]. This experiment showed better accuracy with that of contact electrocardiography sensor by the values generated by LF and LF/HF measured units through remote sensors. The MEM method was demonstrated to generate accurate information on HRV successfully for the first time by estimating the variations of HRV that determine mental stress levels

### Health monitoring through wearable remote sensors

Wearable remote sensors diagnose the biochemical and physiological activities of a human body using motion sensing[7,38]. Physiological monitoring methods analyze initial diagnosis and proceeding treatments with cardiovascular, pulmonary, & neurological diseases using home-based remote sensor systems [30]. Patel [30] had discussed the recently developed IEEE 802.15.4a efficient standard radio with Ultra-wide-band (UWB) impulse having low-cost, low-power, and big data transfer network applications that estimate highly accurate locations. An alert message will be sent to the emergency service center and caretaker to allow quick response based on the recorded data on patient's mobile phone during emergency cases. More than 90% of breathing rates are achievable measured using a microphone attached to the neck by recording acoustic signals and removing environmental noise and other artifacts[11]. A flexible, low-power, ear-worn Photo-Plethysmo-Graphy (PPG) sensor is employed for long-term estimation of heart rate[31]. An accelerometer-based device was designed to count the number of steps taken by Parkinson's suffering patients[14]; a wearable sensor was developed to analyze the patient's recovery after their abdominal surgery [4]. Low-quality of sleep patterns were recorded in mild dementia suffering patients during the preliminary studies [30]. Quality, quantity, and rhythm of sleep pattern through bed pressure sensors and Passive Infra Red (PIR) sensors to monitor the cognitive levels of impairment.

## RS FOR CONTACTLESS HEALTHCARE APPLICATIONS

### Contactless Health Check-ups

Remote medicine and contactless inspections became the global standards due to the sudden outbreak of the Covid-19 pandemic. Contactless inspection using Near Infra Red (NIR) spectroscopy is at its peak during mass inspections, producing real-time accuracy and reducing the risk of secondary infections. Rapid screening of passengers within 5 seconds was conducted at quarantine stations where the people suffering from SARS (Severe Acute Respiratory Syndrome) or pandemic influenza[15]. The system also involves body temperature, respiratory rate, and heart rate estimations using infrared thermo graphy [22,23]. The final output highlighted the system's efficiency, even detecting an infected patient whose fever was decreased by anti febrile medication[15]. This study reveals the importance of sensors in effectively monitoring cardiac and respiratory activities.

## RS FOR EPIDEMIOLOGICAL HEALTHCARE APPLICATIONS

### Malaria

Malaria disease cases were recorded in over 100 countries and 40% of world's population is under risk. The spread of malaria is greatly connected with environmental aspects that control the maturity of the mosquitos' and its parasite growth. Ahmed [1] had applied Multi-Criteria Evaluation (MCE) procedure to evaluate several priority in order to generate risk map such as the factors of slope, wetness index, distance to stream, elevation, vulnerability (accessibility index), Land Use Land Cover (LU/LC) and distance to breeding sites[1]. Standard raster layers were generate using eigen vector computed in Arc GIS 9.2 /AHP extension software and assigned appropriate weight ages. Maps of malaria hazard zonation of very high, high, moderate, low and very low areas were successfully extracted [1].





Manjunatha et al.,

### Filaria

India is one of the highly vulnerable country for filariasis transmission due to its prevailing climate, landscape and environmental conditions. Palaniyandi [29] had experimented with the Digital Number (DN) values from 145 to 158 of RS satellite sensor generated through NDVI calibration support valuable and statistically significant in mapping of filariasis transmission and its risk analysis. The combination of temperature (16-30 degree Celsius), relative humidity (40-90), average annual rainfall (300-1200 mm) and altitude (0-600 m MSL) shows better accuracy among other possible geo-climatic conditions[29]. A strong and well supported relationship had recorded between filariasis and geo-climate variables through linear multivariate analysis with ranks ranged 1 to 7 [29]. These ranks were classified into 3 categories of highly risk zones (66-100); moderately risk zones (33-66) and safe zones (<33) of filariasis transmission risk [29]. The obtained filariasis transmission risk zones suits best over the observed endemicity level that is statistically significant. Geo-statistical modeling of filariasis transmission risk zones of vast geographical area is highly accurate, cost benefit in controlling methods at the grass-roots-level [29].

### Japanese Encephalitis (JE)

Nearly 50,000 JE cases were recorded per annum from the peoples of Indian Subcontinent, Southeast Asia, Japan, Korea and China. The chances of increase in JE cases was observed with rise in precipitation, land use and temperature that favors the development of mosquitoes. Only one case develops encephalitis out of 250 infections that leads to drowsiness, dilated pupils in the initial stage whereas headache with fever and vomiting during later stages. JE cases were observed from 54 districts out of 75 in Nepal with highest incidence rate from the age group between 5–15 years[26]. Risk of JE starts to decrease as the precipitation increases from certain threshold value more than 180 mm per month. Similarly, very high temperatures also tends to decrease the number of mosquitoes and consequently decrease the JE cases, but cultivated area of paddy field are more prone to JE[26]. Mishra[26] had applied a composite combination of precipitation, temperature and paddy fields as factors using multivariate regression analysis that may help in predicting the JE expected cases. The disease is seasonal and mainly observed from the months of June to October and high-rise incidences during July to August due to the support of prevailing climatic conditions for mosquitos breeding[26].A lag time of one month is best suited and applied in JE prediction model.

### Google Earth Engine (GEE)

Google Earth is an easy handling stand-alone free software that has great potential to improve public healthcare services. It provides high quality Land sat imagery of urban infrastructures, road connectivity, physical environment, streets, rivers, lakes and locations of hospitals with simple editing tools. Geo-explorers use GEE for RS research, disease outbreak maps & its trend, natural resource management, and more. Cholera outbreak cases were recorded in Maruthinagara village (population-3180) of Bengaluru Urban district, India during June 2013 lasted for 11 days (8<sup>th</sup> -18<sup>th</sup> June, 2013)[32]. The outbreak of cholera was observed mainly due to low socio-economic status, drinking water supply without purification process, open-air defecation nearby water supply, no chlorination of water, leakage of water supply and poor environmental hygiene [32]. It is possible to record the cases permanently and cross-checked independently for future trend analysis using GEE and GPS instrument. A spot map had prepared by Ramesh [32] with an accurate analysis of contamination source, households where cases occurred, the locality and distances to nearest healthcare centres[32]. The advantages of this spot maps on GEE will be certainly helpful for the people living nearby infected cases, only if these data available at an affordable cost in real-time.

### Drones for Medical emergency

Identifying smaller stagnant water bodies are the major challenge in managing and monitoring diseases where mosquitoes use to breed. Zanzibar Malaria Elimination Program, Tanzania, adopted drone instrument for the first time in 2019 to fight against Malaria disease on the island of Zanzibar[17]. Drone instrument tested to spray silicon-based liquid on stagnant water noticed in within the areas of rice and paddies, where mosquitoes lay their eggs. Silicon-liquid had prevented the eggs from hatching by spreading across the stagnant water and the infection levels had consistently reduced from 40% to less than 10% in parts of Zanzibar [17]. Drone imagery create precise and



**Manjunatha et al.,**

accurate maps of potential habitats by covering 30 hectares of rice, paddy areas within 20 minutes. These imagery proved to be highly accurate and efficient in locating exact spots of stagnant water bodies.

## RS FOR ENVIRONMENTAL MONITORING IN HEALTHCARE APPLICATIONS

### Landfill sites selection through RS

Nationwide Union Urban Development Ministry (NUUDM) recognized Mysuru city of Karnataka State as the second cleanest city in India during the year 2015, 2016, 2018 and 2020. It produces nearly 800-900 tons of solid waste daily that require larger landfill sites for future waste disposal[6]. The existing treatment plant at Vidhyaranyapuram is designed to treat 150-200 tons of solid waste to process compost and nearly 700 tons of solid wastes were dumped as untreated. The existing landfill site is noticed within the core zone of Mysuru city and presently acting on a minor lineament connected to a major lineament contributing to the leaching of toxic materials and effluents contained in the heavy dumped wastes during heavy rainfall seasons. Overlay of important thematic layers of geomorphology, lithology, lineament, drainage, slope, soil, transportation networks, and vegetation showed interesting suitable locations within the buffer zone for proper sorting and scientific way of municipal solid waste disposal. The thematic map integration applied through RS & GIS yields more accurate and valuable information in identifying suitable landfill locations to keep effluents and toxic wastes away from drainage, lineament, loamy types of soils, sedimentary rocks, sloppy areas, National Highway (HW), vegetation and other major factors[6].

### Groundwater contamination through RS

Storage and movement of groundwater are most supported by lineaments and fractures especially in igneous and metamorphic terrains [6,9]. Folds, faults, joints, fracture, bedding plains, shear zones, unconformities were recorded at many locations of Chitradurga district as secondary porosities in allowing groundwater circulation[6]. Structural lineaments and land use land cover patterns were extracted by PAN+LISS-III of IRS satellite image using PCI-Geomatica v10. Extracted structural lineaments were overlaid on LU/LC categories to disclose the specific locations or possible sources of groundwater contamination occurring through urban run-off; agricultural activities; municipal solid waste dump sites; mining (iron & manganese)/ industrial operations; salt affected lands. 144 numbers of industries/ factories and 57 mining leases (barites, pyrite, copper, clay, dolomite, limestone, fuchsite quartzite, manganese di-oxide) were noticed to be working on most of the minor and major lineaments that adding effluents to the groundwater[6]. Huge applications of fertilizers, herbicides, chemicals, pesticides in agricultural fields were the major factors that adding nitrate content in rock formations and soil types leaching through joints, fractures and seepage (major lineaments) areas and contaminated the groundwater quality[6].

### RS for Heat-Related Health effects

Heat wave disaster in Europe (2003) and Russia (2010) had Albright recorded high death tolls of 70,000 and 55,000 respectively[5,34]. Extreme Heat Events (EHE) is one among the severe meteorological disasters that may rise in its intensity, frequency and duration of future global warming[24] that may cause both weather related morbidity[39] and human deaths in extreme cases[18]. Chen [10] had utilized MODIS images of Land Surface Temperature (LST) with 1km spatial resolution during day and night time periods. MODIS data on 7<sup>th</sup> Aug 2013 was acquired since the cities of Yangtze River Delta (YRD) recorded highest air temperature of 40 triangle degree Celsius [10]. Two cloud free MODIS LST data was acquired for both daytime (10:30 am) and nighttime (1:30 am) of same day and processed with Albers conical equal area projection of 250m[10]. Crichton's risk was utilized to generate spatial heat health risk framework, since the natural disasters are the characteristic functions of human exposure, vulnerability and hazards[10]. Spatial gradient maps were generated to showcase the heat hazard index with increased temperature for Extreme Heat Events (EHEs) and estimated through satellite Land Surface Temperature images across Yangtze River Delta region[10]. Built-up land overlaid with multisource data was obtained as gridded human exposure index that has best suited with hazard layer at specific spatial scale[10]. Index layers of human exposure, heat vulnerability and a normalized heat hazard were considered for multiplication by equal weight ages in generating output map of heat health risk index layer as standard conclusion[19,33].





**Manjunatha et al.,****Spectral Radiometer for Heavy metal contamination analysis**

Hyper spectral Remote Sensing (HRS) received recent attention for exploring the recognition of metal and its stress on vegetation cover (Vegetation Indices) in the environment. Arsenic has been used widely in wood treatment, pesticides[28], and chemical warfare weapons as a base compound[2]. Heavy metal contaminations during their applications in the industries and urban floodplains contribute to the addition of arsenic[25], lead, zinc and selenium in the soil and vegetation cover. Excessive exposure to these metals has a deleterious impact on plant photosynthesis and stress[35]. The loss of photosynthesis absorption is noticed at 680 nm with high reflectance due to arsenic contamination in the soil and an increase in shortwave infrared reflectance representing water loss[35]. Identifying stresses and their patterns are necessary for plant biochemistry and photosynthetic processes in vegetation health analysis. Thus, applications of HRS showed successful analysis in enhancing the spectral responses of specific metals in soil and its environmental monitoring[35].

**RS applications for Air Pollution monitoring**

EO satellites support health and air quality monitoring in managing the public health and recording its impacts on environmental issues. Somvanshi[36] had utilized Landsat-8 satellite image efficiently in monitoring the air pollution levels of Delhi region. Continuous air quality samples were monitored and collected from 18 stations of CPCB and collected PM<sub>10</sub> from industrial, commercial and residential areas[36]. Fuelwood burning, agricultural waste burning, vehicular emissions were the major sources of PM<sub>10</sub> pollutant noticed in Delhi region affecting largely on haze, heart stroke, lung/liver cancer, bone problems, liver fibrosis, visibility reduction and respiratory issues[36]. The band combination 2, 3, 4 of Landsat-8 reveal better model for mapping and prediction of PM<sub>10</sub> indicating 67% of variance in its value with strong correlation and higher concentration between 149 and 856 mg/m<sup>3</sup> impacting major parts of Delhi region. This work acts as a model for future prediction of air pollutants for risk characterization & mitigation and policy makers in their planning and preparations[36].

**RS, GIS AND GPS INTEGRATED APPS FOR HEALTHCARE SERVICES****Location-based spatial services**

Geo Health is a location-based software application discussed by Kjeldskov [20] for health care-taker of patients at their houses within the vast geographical area. A bird view of satellite images with certain tools of zooming, Left/Right, Up/Down key sare effectively utilized in mapping of patient's locations and their respective care-takers using GPS data in planning a proper tasks and shortest routes[20]. A dialogue box is made to appear while clicking on a patient's name and provides all related information in performing regular check-ups and necessary treatment in the hospital. Later the updated information will be automatically sent to the respective care-taker/ healthcare worker through registered phone number and an immediate Skype-Out call is also available as an option to the patient's laptop[20]. Geo Health app contains a close-up satellite image with nearby landmarks that highlights the patient's address to reach timely with shortest distance by their respective healthcare workers. During an unavailability of a healthcare worker, Geo Health app facilitates easy swapping of work schedules among healthcare workers by dragging a patient's icon onto nearby another location of health care-taker[20]. The app triggers alarm during the medical emergencies and a pop-up message will be sent to the nearest healthcare centres and location of 2 nearby healthcare workers. If one of the coworker rejects the alarm, then it will be sent directly to the next nearest person and so on[20].

**Emergency Medical Services (EMS)**

A quick ambulance response time is crucial in emergencies and life-threatening cases such as cardiac arrest. US EMS covers 95% of all received emergency calls within 10min in urban areas, saving most patients' lives. Almadani conducted an E-Ambulance framework model that generated healthcare monitoring for remote medical professionals[3]. Data Distribution Service (DDS) is the standard model built to supply connections between ambulance drivers with respective hospitals using GPS to evade traffic jams and transport the patients to the nearest suitable healthcare centres as quickly as saving the patient's life. Biosensors, intelligent units, actuators, Global Positioning System (GPS) components, and technologies were employed to achieve this mission[3]. The updated ambulance location can be monitored for tracking/ guiding by remote traffic management and medical healthcare







Manjunatha et al.,

centers. The sensor networks installed within the ambulance are wearable biosensors that measure and convey health status data to paramedic staff inside an ambulance while traveling to the hospital. The medical center will follow proper remote decisions and guide the paramedic staff inside the ambulance. The probability of saving lives will positively increase and furnish specific utilization of healthcare facilities before E-ambulances arrive at the respective hospitals.

## CONCLUSION

Spatial data, combined with cutting-edge technologies, has greatly aided the public healthcare sectors in solving complex problems and developing the medical science field. RS technology may provide healthcare scientists with a faster and more current data source and data analysis than traditional methods. Low-cost, low-power remote monitoring systems are highly required in the near future for patient monitoring applications in their residences. RS capabilities in disease surveillance, services, safety, control, and environmental factors by integrating suitable spatial modeling of GIS and GPS. Thus, Earth Observation (EO) satellites support healthcare, services, air quality monitoring and ease in managing the public health and recording its impacts on environmental issues.

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## Biosynthesis of Silver Nano particles using Microbes

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### ABSTRACT

The process of biosynthesizing silver nano particles is currently the most rapidly growing process in nanotechnology. Silver nano particles, or AgNPs, are recognized for their bactericidal properties and have been shown to be an effective antimicrobial agent against pathogenic bacteria that have emerged due to genetic mutations. This study focuses on creating metallic bio nano particles of silver through the reduction of aqueous Ag<sup>+</sup> ions with the culture supernatant of *S.aureus*. The reduction of Ag<sup>+</sup> ions in the solution was monitored in the aqueous system. The silver nano particles were analyzed using UV-visible spectrophotometers and FTIR (Fourier transform infrared spectroscopy).

**Keywords:** *S.aureus*, Silver nitrate, UV-visible, FTIR





Chitra Rathod et al.,

## INTRODUCTION

Nanotechnology refers to the manipulation of molecules to design, characterize, produce, and apply materials at the nanometer scale. The term "nanotechnology" was first coined by Norio Taniguchi in 1974, although it was relatively unknown at the time. Nano materials, a field of materials science based on nanotechnology, involves the synthesis of various nano materials, including copper, zinc, titanium, magnesium, gold, alginate, and silver. Silver nano particles are among the most widely used nano materials. They are used in a variety of industries, including antimicrobial agents, textile industries, water treatment industries, cosmetics industries, and more. Silver is a safe and nontoxic antibacterial agent that has been used for centuries to kill various types of disease-causing microorganisms. In recent years, the use of silver as a biocide in solution, suspension, and mostly in nanoparticle form has increased gradually due to its remarkable antimicrobial activity. The strong antimicrobial activity of AgNPs is one of the reasons for the recent increase in the development of products that contain nanosilver. Many biological approaches for both extracellular and intracellular nano particle synthesis have been reported to date using microorganisms, including bacteria, fungi, and plants. These approaches offer a sustainable and eco-friendly method for synthesizing nanoparticles. Overall, nanotechnology and nanomaterials have a wide range of applications and are an emerging field of science that is constantly evolving. The use of silver nanoparticles is just one example of how nanotechnology is being used to improve various industries and products.

## MATERIALS AND METHODS

**Material used :** Soya bean casein digest medium (Himedia grade MH011), silver nitrate, nutrient agar (Himedia grade M001), distilled water

Instruments used: Autoclave, incubator, rotary shaker incubator, centrifuge, UV-visible spectrophotometer, FTIR, and microwave oven

**Media preparation :** Weigh soybean casein digest medium at 29.77 grams in 1000 ml of distilled water. Boil to dissolve the medium completely, then sterilize by autoclaving at 121°C & 15 lbs. pressure for 15 minutes.

**Method :** *S.aureus* was grown in soya bean casein digest medium as well as sub cultured in the microbiology laboratory (Department of Applied Science, Parul University, Vadodara, Gujarat, India) during the study time.

**Biosynthesis of silver nano particles (AgNPs) :** The *S.aureus* strain was freshly inoculated in SCDM medium. *S.aureus* strain was inoculated for 24 hours at 37°C. After these organisms are streaked on a nutrient agar slant to store *S.aureus* for long time, The *S.aureus* NCIM 5345 strain was freshly inoculated in SCDM medium and incubated for 24 hours at 37°C. The culture was centrifuged at 10000 rpm for 10 minutes, and the supernatant was used for the synthesis of silver nanoparticles. After the centrifugation process was completed, silver nitrate was added to the supernatant. After adding the silver nitrate solution, broth was incubated at 30–35 °C for 72 hours in a rotary shaker incubator. After 72 hours of incubation, a clearly brown colour developed in a flask that was showing silver nano particle formation in it. From this solution, a small amount of sample was collected for UV-visible spectroscopy. The solution was then centrifuged at 10000 rpm for 10 minutes, and pellets were collected in a petri dish and dried in an oven at 80°C. The sample was sent for FTIR (Fourier transform infrared spectroscopy).

## RESULTS AND DISCUSSION

In recent times, there is a growing need for the biosynthesis of silver nanoparticles to combat mutated microorganisms that have developed resistance against most drug substances. Biosynthesized silver nanoparticles offer a more powerful antimicrobial agent that does not involve any chemical redox reaction, making it an eco-friendly solution. The silver nanoparticles were produced using the cell-free supernatant of the *S.aureus* organism, which has been shown to release the nitrate reductase enzyme in previous studies. This enzyme can produce silver nanoparticles when mixed with a silver nitrate solution. To confirm the formation of silver nanoparticles, a UV-Visible spectrum scan was performed on the collected sample using distilled water as a blank.







Chitra Rathod et al.,

The maximum absorbance was found at 412 nm, which confirms the formation of silver nanoparticles. Additionally, FTIR spectroscopy was conducted to further confirm the formation of silver nanoparticles. The peak at 1377/cm indicates the presence of C-H medium bonding with an aldehyde group, while the band at 1632/cm corresponds to C=C medium bond with an alkene group. The peak at 2369/cm indicates the presence of O=C=O with fundamental stretching vibrations of CO<sub>2</sub> group and strong aliphatic vibrations. Other peaks correspond to silver ions. In summary, the biosynthesis of silver nanoparticles offers a powerful and eco-friendly antimicrobial agent that can combat mutated microorganisms. The use of *S.aureus* organism and nitrate reductase enzyme to produce silver nanoparticles has been proven effective and can be confirmed through UV-Visible spectrum scan and FTIR spectroscopy. The objective of this study was to investigate the biosynthesis of AgNPs through an extracellular process using *S.aureus*. This method was chosen for its simplicity, cost-effectiveness, and ability to produce stable nanoparticles. The reduction of Ag<sup>+</sup> ions was evident when the supernatant of *S.aureus* was added to AgNO<sub>3</sub>, as the color changed from yellow to yellowish-brown. This change in color indicates the formation of AgNPs. By utilizing an extracellular process, the researchers were able to simplify the synthesis of AgNPs and make it more cost-effective. Additionally, the use of *S.aureus* allowed for the production of stable nanoparticles, which is essential for their practical use. The visible reduction of Ag<sup>+</sup> ions and change in color further confirms the successful formation of AgNPs. Overall, this study demonstrates the effectiveness of using an extracellular process with *S.aureus* to biosynthesize AgNPs. The simplicity and affordability of this method make it a promising approach for large-scale production of stable nanoparticles. The visible change in color provides a simple and effective way to confirm the formation of AgNPs.

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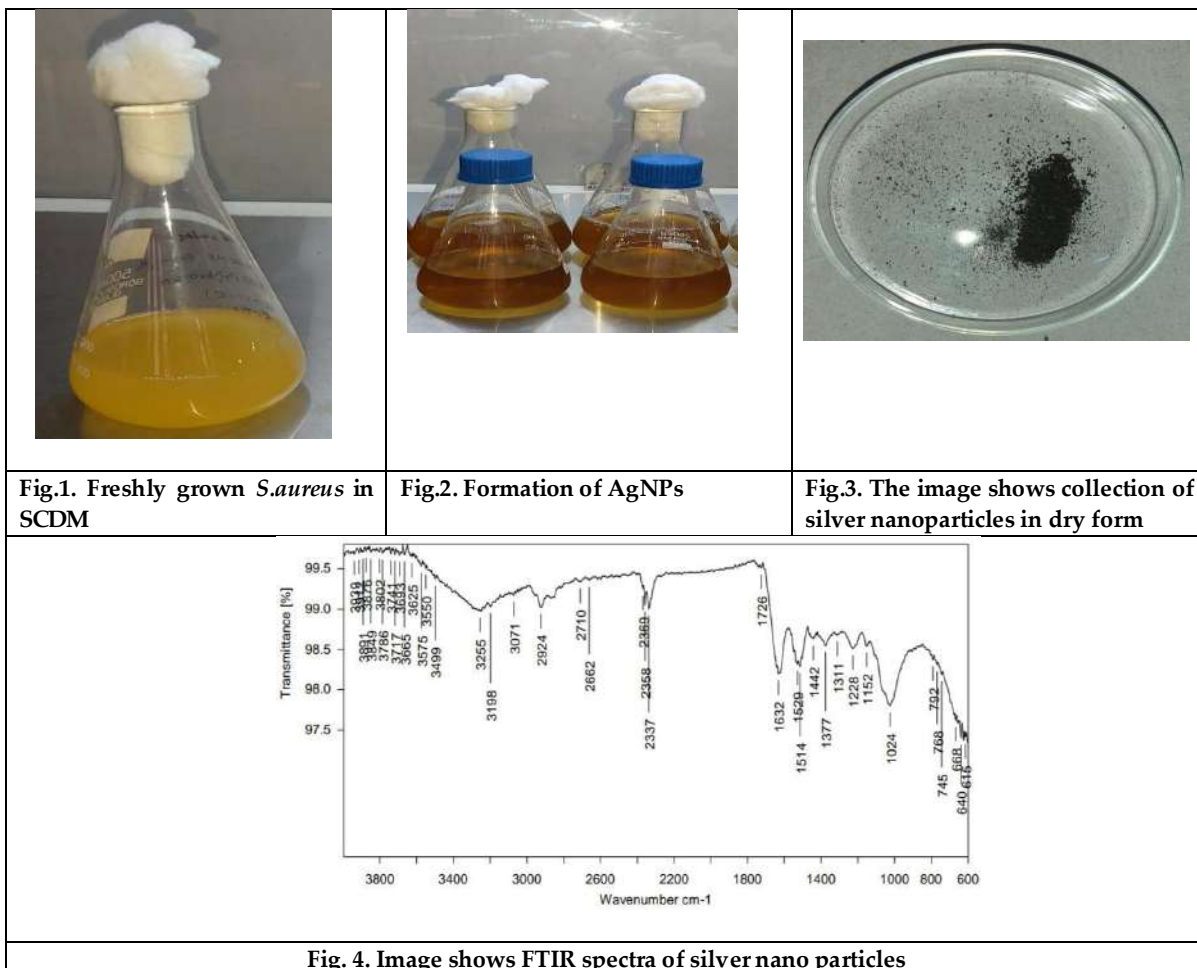






**Chitra Rathod et al.,**

- nanoparticles confirmed by TEM and UV Vis spectroscopy.
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  - Nanomaterials and nanotechnology 2016, 6:29 Muhammad Ashraf Sabri Bacteria, Fungi and plants are capable for reducing silver ions to metallic silver nanoparticles. They have been tested with different bacteria, fungi and plants extract also.





## The Impact of the Tamil Nadu Pollution Control Board in Regulating River Pollution - A Study

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### ABSTRACT

Rivers are precious natural resources that nature has endowed. But, in recent decades, rivers have suffered significant impacts from developmental activities such as industrialization and urbanization. In this context, the Tamil Nadu Pollution Control Board (TNPCB) plays a crucial role in safeguarding the environment of rivers in Tamil Nadu. The board shoulders the immense responsibility of enforcing environmental laws and regulations to protect the environment. Nonetheless, the ecological degradation of rivers remains a critical issue, and the TNPCB faces challenges in effectively addressing this degradation. Through semi-structured interviews with board members and other stakeholders, this research aims to identify the problems faced by the TNPCB and provide appropriate recommendations to enhance the board's effectiveness in tackling ecological degradation.

**Keywords:** Tamil Nadu Pollution Control Board (TNPCB), Environment of Rivers, Ecological Degradation, Natural Resources, Environmental Laws.

### INTRODUCTION

River pollution, which has become a crucial environmental issue, has a significant impact on the major rivers in Tamil Nadu, a state in the southern part of India. Pollution has had a negative impact on the Cooum, Adayar, Noyyal, Thamirabarani, Vaigai, Amaravathi, Bhavani, and Cauvery rivers, which are important for maintaining ecosystems and assisting local residents. Industrial discharges, sewage pollution, and poor waste management



**Naveenkumar and Subramanian**

practices are the main sources of (Norman, R. S. 1974) contamination in these rivers. Heavy metals and harmful contaminants have been found in the rivers as a result of industries along riverbanks, especially in the most industrialized cities and towns, dumping untreated effluents into the waterways. Sewage from residential and commercial buildings that frequently don't have enough underground sewer connections runs directly into the rivers, further degrading the water quality. Sewage treatment plants that aren't working properly make the problem even worse. Tamil Nadu's river pollution has far-reaching effects. The build-up of toxic materials harms marine life and ecosystems and causes widespread extinctions of fish and other aquatic species. Using contaminated water for irrigation reduces the fertility of the land, creating new difficulties for agriculture. A comprehensive strategy that includes (Rajan, A et, al 2016) effective regulation, the enforcement of environmental standards, public education, and environmentally sound waste management procedures is needed to address river pollution. The 1982-founded Tamil Nadu Pollution Control Board (TNPCB) is essential to the implementation of environmental laws and regulations to safeguard the local rivers. Due to its limited power, problems with coordination, and resource shortages, the TNPCB finds it difficult to effectively address the ecological degradation of rivers. This study intends to evaluate the TNPCB's obligations and role in controlling river pollution, as well as the obstacles and constraints it encounters. It is possible to make appropriate recommendations to improve the Tamil Nadu Pollution Control Board's effectiveness in protecting the environment and maintaining the health of Tamil Nadu's rivers by studying these aspects.

**OBJECTIVES OF THIS STUDY**

The objectives of this study are twofold. Firstly, it aims to assess the role and responsibilities of the Tamil Nadu Pollution Control Board (TNPCB) in implementing environmental laws and regulations to protect the rivers in the region, with a particular focus on the Noyyal River Basin. This includes examining the effectiveness of the TNPCB in fulfilling its regulatory duties and promoting environmental conservation. Secondly, the study seeks to identify the challenges and limitations faced by the TNPCB in effectively addressing the ecological degradation of rivers, including pollution and other environmental concerns. Based on the findings, suitable recommendations will be proposed to enhance the board's performance and strengthen its capacity to safeguard the environment in the region. The study aims to contribute to the understanding of the TNPCB's role, highlight areas for improvement, and provide valuable insights for policymakers and stakeholders in their efforts to protect and restore the ecological integrity of the rivers in the Noyyal River Basin.

**SCOPE OF THE STUDY**

The significance of this study lies in its examination of the impact of the Tamil Nadu Pollution Control Board (TNPCB) in regulating river pollution. By assessing the effectiveness of the TNPCB's regulatory measures, the study contributes valuable insights to the field of environmental management and policy. Understanding the role and performance of the TNPCB in addressing river pollution is crucial for developing targeted strategies and interventions to mitigate environmental degradation. The findings of this study can inform policy decisions, enhance pollution control measures, and promote sustainable practices in river basins. Additionally, the study's scope extends to evaluating the challenges faced by the TNPCB and proposing recommendations to improve its performance, thus contributing to the development of more efficient and effective pollution control strategies in the region.

**Area of the study**

The area of study in this research focuses on investigating the impact of the Tamil Nadu Pollution Control Board (TNPCB) in regulating river pollution. Specifically, the study examines the effectiveness of the TNPCB's regulatory measures and their implications for controlling and mitigating river pollution. It explores the TNPCB's role, responsibilities, and performance in addressing pollution issues in river basins. By analyzing the impact of the TNPCB's actions, this study aims to provide valuable insights into the effectiveness of pollution control measures and contribute to the body of knowledge in the field of environmental management and policy.





## METHODOLOGY

This research utilizes multiple methods for data collection to obtain a comprehensive understanding of the Tamil Nadu Pollution Control Board's (TNPCB) role in regulating river pollution. Primary data is gathered through interviews and open-ended questionnaires with TNPCB members and social activists engaged in river pollution control. Purposive and snowball sampling techniques are employed to select participants from the TNPCB and social activist groups, respectively. Qualitative analysis techniques are used to analyze the interview data, while document analysis of relevant documents supports the findings. The integration of primary and secondary data sources enhances the validity and depth of the findings, providing a holistic understanding of the TNPCB's impact in regulating river pollution.

## RESULT AND DISCUSSION

### Environmental Legislation in Tamil Nadu

To combat and manage all types of pollution, including river pollution, the state of Tamil Nadu has put in place a comprehensive framework of environmental regulations. These laws and rules are essential for preserving the environment, encouraging sustainable growth, and guaranteeing the welfare of the local populace. The Water (Prevention and Control of Pollution) Act of 1974, one of the main laws in force, has undergone modifications over time to increase its efficacy. This act provides the legal framework for managing and preventing water pollution, particularly river contamination. It gives the State Board the authority to enact pollution prevention policies and establish guidelines for the discharge of contaminants into bodies of water. The Tamil Nadu Water (Prevention and Control of Pollution) Rules, 1983, provide particular guidelines and regulations customized to the needs of the state in combination with the Water Act. These regulations set forth the responsibilities and authority of the State Board's Chairman and Member-Secretary, ensuring effective administration and the implementation of pollution control measures. The Air (Prevention and Control of Pollution) Act of 1981 and the Tamil Nadu Air (Prevention and Control of Pollution) Rules of 1983 address concerns about air pollution, particularly emissions that can have an (Gopal, K. 2003) impact on rivers and other bodies of water. In order to prevent their negative impacts on the environment, these laws seek to restrict industrial emissions, vehicular pollution, and other causes of air pollution. The state also abides by the Environment (Protection) Act of 1986 in order to protect the environment as a whole. The union government has the authority to implement this act's environmental protection and improvement measures. It addresses a wide range of environmental concerns, including resource conservation, management of hazardous waste, and environmental impact studies. To address various facets of environmental preservation and pollution management, the Tamil Nadu government has put in place a number of specialized rules and regulations. These regulations cover a variety of topics, such as how to handle hazardous chemicals, how to manage e-waste, how to manage waste, how to manage noise pollution, how to manage waste in coastal regulation zones, how to manage waste, how to manage waste, how to manage public liability insurance, and more. A wide range of laws, rules, and regulations are included in the environmental legislation framework with the goal of reducing pollution, safeguarding natural resources, and (Amirante, D. 2011) promoting sustainable development. The state's dedication to protecting the environment and fostering a cleaner, healthier future for its citizens is reflected in these initiatives.

### Role of Tamil Nadu Pollution Control Board

The Government of Tamil Nadu established the Tamil Nadu Pollution Control Board (TNPCB), an important regulatory body, on February 27, 1982. It was created in response to the Water (Prevention and Control of Pollution) Act of 1974 (Central Act 6 of 1974), which was passed with the intention of resolving the state's urgent water and air pollution problems. The Water (Prevention and Control of Pollution) Act of 1974, the Air (Prevention and Control of Pollution) Act of 1981, and the Environment (Protection) Act of 1986, together with the corresponding rules, have all been enforced with significant help from the TNPCB over the years. Planning, implementing, and overseeing extensive programs for the prevention, control, and abatement of water and air pollution are the main duties of the



**Naveenkumar and Subramanian**

TNPCB. To effectively address pollution challenges, plans and guidelines must be developed. The TNPCB also serves as a consultative body to the Tamil Nadu State Government, offering knowledgeable advice on issues pertaining to pollution prevention, control, and abatement. The collection, analysis, and dissemination of information about water and air pollution, as well as strategies to counteract it, are important components of the work done by the Tamil Nadu Pollution Control Board. This entails doing routine assessments of the efficacy of sewage and trade effluent treatment plants, examining plans and specifications for remedial procedures, and assuring adherence to specified standards. The TNPCB conducts inspections of industrial facilities and production processes, checks out control mechanisms, and offers recommendations for the prevention, control, or abatement of air pollution. In order to analyze the quality of the air and take the necessary action to reduce pollution in certain places, it also evaluates air pollution control areas. The TNPCB develops, alters, or annuls effluent (Amirante, D. (2011) regulations for sewage, trade effluents, and emissions of air pollutants as part of its attempts to preserve environmental standards. It establishes rules for how industrial facilities, automobiles, and other sources should release air pollutants into the atmosphere. The TNPCB also concentrates on creating sewage and trade effluent treatment technologies that are commercially feasible.

The TNPCB's work is heavily reliant on monitoring and assessment. The board gathers samples of sewage, industrial effluents, and air pollution emissions and performs an in-depth investigation to establish precise specifications. This information helps in assessing pollution levels and locating places that need immediate attention and corrective action. Another crucial part of the TNPCB's duty is cooperation with the Central Pollution Control Board. It actively contributes to team (Amirante, D. 2011) initiatives by setting up training courses for people taking part in or preparing to take part in actions aimed at preventing, controlling, or reducing water and air pollution. Additionally, the TNPCB runs widespread education campaigns to promote environmental protection among the general populace. The TNPCB's membership is made up of a wide variety of people. It consists of a full-time Chairman, State Government nominees, local authority representatives, non-officials representing agriculture, fisheries, industry, or trade interests, individuals representing state-owned businesses or enterprises, and a full-time Member Secretary. The TNPCB's mission is to build alliances with stakeholders for ethical and sustainable development. This demonstrates the board's dedication to working with different organizations to promote sustainable practices and preserve the environment. The TNPCB has devised a three-tier organizational structure to streamline its operations. It has a Chennai-based head office, eight zonal offices run by joint chief environmental engineers, and 38 district offices run by district environmental engineers. These offices enable efficient industry (Sankar, U. 2000) monitoring and regulation throughout the state. The TNPCB established District Environmental Laboratories and Advanced Environmental Laboratories to complement its regulatory tasks. These labs analyze sewage, industrial effluents, emissions, and hazardous waste samples, which helps with the overall evaluation and monitoring of pollution levels. The TNPCB is intimately linked to several environmental laws. It oversees adherence to laws like the Environment (Protection) Act of 1986, the Air (Prevention and Control of Pollution) Act of 1981, the Water (Prevention and Control of Pollution) Act of 1974, and several related rules and notifications. These laws cover a wide range of topics, such as noise pollution regulation, hazardous waste management, environmental impact assessment, and more. In Tamil Nadu, the Tamil Nadu Pollution Control Board (TNPCB) is essential for the prevention, management, and reduction of air and water pollution. The TNPCB seeks to safeguard and conserve the state's natural resources while fostering sustainable development with its extensive programs, monitoring systems, and enforcement of environmental laws.

**An overview of Tamil Nadu's river pollution**

River pollution, a recurring environmental issue in the state, has had a negative impact on all of Tamil Nadu's major rivers. The main contributors to the pollution in these rivers are industrial discharge, sewage contamination, and poor waste management techniques. One of the main causes of river pollution in Tamil Nadu is industry along the riverbanks. Heavy metals and harmful contaminants have contaminated the water as a result of numerous industrial operations, especially in the in towns and cities, discharging untreated effluents directly into the rivers. These industries' inadequate effluent treatment facilities have increased pollution levels, having negative environmental effects. In Tamil Nadu, sewage pollution is a significant additional cause of river pollution. The direct release of





**Naveenkumar and Subramanian**

untreated sewage into the rivers occurs because many homes and commercial buildings near riverbanks do not have enough underground sewer connections. This sewage contains dangerous chemicals that endanger not just human health but also marine life and the purity of the water. River contamination has increased as a result of existing sewage treatment plants (STPs) not operating properly or being underutilized. Many STPs leak untreated water into rivers because they are not properly operated or maintained. As a result, harmful substances gather and the general quality of the water deteriorates. Tamil Nadu's river pollution has far-reaching effects. The high concentrations of hazardous chemicals, heavy metals, and other harmful substances in the water have a negative impact on both people and marine life. The contaminated water harms marine life, which causes fish and other aquatic creatures to die off in large numbers. As dirty water is frequently utilized for irrigation, river pollution also has an impact on the fertility of the soil. The National Green Tribunal (Southern Bench) and the Tamil Nadu Pollution Control Board (TNPCB) have taken actions to increase the number of treatment facilities in industries and impose harsher restrictions in order to solve the issue of river pollution. In order to ensure that industries treat their effluents before releasing them into rivers, efforts are being made in this direction. To reduce sewage pollution, proper underground sewer connections must be made, and current sewage treatment facilities must perform better. To protect the wellbeing of rivers and the ecosystems they support, the problem of river pollution in Tamil Nadu requires a comprehensive solution that includes effective legislation, enforcement of environmental standards, public awareness, and sustainable waste management techniques.

**TNPCB's Monitoring and Assessment Programs**

River pollution monitoring systems have been put in place by the TNPCB to measure and track the levels of river pollution in the River basin. These tactics entail routine water quality parameter sampling and analysis at selected monitoring stations along the river. In order to gather information on pollution levels and evaluate the general condition of the river, the board uses a variety of monitoring techniques and tools. The TNPCB has acknowledged specific water quality measures as crucial indicators of pollution in the Cauvery River basin. These measurements include pH values, total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), and a number of other chemical and biological factors. In order to regularly collect samples and analyze these data, the board has set up monitoring stations along the river at important points. More recently, the board has also implemented a live time monitoring system for the effective and continuous monitoring of river pollution. The TNPCB uses organized techniques for data collecting and analysis to efficiently monitor and evaluate the pollution levels in the basin of the Cauvery River. In order to examine the water quality parameters, the board gathers water samples from the monitoring stations and performs laboratory testing. The gathered information is then organized and examined to spot trends, patterns, and likely pollution sources. When creating suitable pollution control and management measures, this knowledge is essential. The Central Pollution Control Board and the appropriate government agencies will receive this report.

**TNPCB's Enforcement Measures:****Compliance monitoring and inspection**

The TNPCB regularly monitors compliance and inspects businesses, factories, and other pollution sources in river basins. The Tamil Nadu Pollution Control Board members have the authority to visit industries and conduct inspections.

The board makes sure these organizations follow the environmental laws and guidelines established by the National Green Tribunal and the government. Inspections are conducted to determine the status of compliance, spot any violations, and implement the appropriate corrective measures.

**Legal actions and penalties for non-compliance:**

The TNPCB pursues legal action against polluters when environmental regulations are broken. To compel compliance, the board has the power to impose warnings, fines, and even bring legal action. These measures operate as deterrents to make sure that businesses and other organizations operating in the River basin follow pollution prevention protocols and safeguard the environment.





**Naveenkumar and Subramanian****Collaboration with other agencies and stakeholders**

The TNPCB is aware of how crucial cooperation with other organizations and interested parties is in resolving environmental problems in the Cauvery River basin. The board closely collaborates with regional organizations, public works agencies, and other pertinent authorities to coordinate efforts and divide duties for pollution management. This partnership encourages a comprehensive strategy for environmental preservation and improves the effectiveness of enforcement measures. The TNPCB is aware of how crucial cooperation with other organizations and interested parties is in resolving environmental problems in the Cauvery River basin. The board closely collaborates with regional organizations, public works agencies, and other pertinent authorities to coordinate efforts and divide duties for pollution management. This partnership encourages a comprehensive strategy for environmental preservation and improves the effectiveness of enforcement measures.

**CHALLENGES AND LIMITATIONS**

In order to effectively regulate pollution in the river basins, the Tamil Nadu Pollution Control Board must overcome formidable obstacles. The board's limited authority to adopt comprehensive environmental policies and initiatives is a significant obstacle. The division of duties for pollution management among many agencies, such as municipal governments and the public works department, makes coordination and enforcement challenging. The Tamil Nadu Pollution Control Board's regulatory framework might not be able to handle all environmental problems in the river basins. The Tamil Nadu Pollution Control Board may not have the requisite jurisdiction to enforce restrictions on other sources of pollution, such as domestic sewage and plastic dumping, although it has the authority to control industrial pollution and take action against polluting industries. Other governmental entities, in particular municipal governments, have jurisdiction over certain areas. As a result, the Board might not have the power to penalize hotels and stores that cause pollution. The Local bodies have these Powers. Due to a manpower shortage, this organization has limitations. The board is unable to often examine and monitor polluting sources due to the size of the river basins. This restriction hampers their ability to effectively control pollution. Expanding the TNPCB's authority and scope of jurisdiction is crucial to address pollution challenges. This involves granting the board the power to legally address pollution sources, including domestic sewage and plastic waste disposal, irrespective of the offending business or industry. Sufficient funding and staff are required for the TNPCB to effectively enforce regulations and conduct regular monitoring. Improved coordination with other government agencies, particularly local bodies, is essential to combat river pollution in the basins. Enhancing communication and cooperation among various departments and organizations involved in pollution management will ensure a consistent and efficient strategy. Advocating for increased power and funding for the TNPCB to tackle other pollution sources, such as domestic sewage and plastic waste, is important. Education campaigns focusing on raising public awareness and participation will heighten public consciousness.

**Implications of the study**

The implications of this study on the impact of the Tamil Nadu Pollution Control Board (TNPCB) in regulating river pollution are significant for various stakeholders. First, the findings provide valuable insights for policymakers and regulators in assessing the effectiveness of the TNPCB's regulatory measures. The study highlights areas of improvement, identifies challenges, and proposes recommendations to enhance the TNPCB's performance in mitigating river pollution. These insights can inform the development of more targeted and efficient pollution control strategies. The study's implications extend to industries and businesses operating in the region.

It emphasizes the importance of compliance with pollution control regulations and the need for sustainable practices to minimize the negative environmental impacts. The study's findings can guide industries in adopting responsible and environmentally-friendly measures, ultimately contributing to their long-term sustainability and reputation. The study's implications benefit local communities and the general public. By evaluating the impact of the TNPCB's actions, the study raises awareness about the importance of river conservation, pollution prevention, and the role of regulatory bodies. It empowers communities to actively participate in pollution control efforts and advocate for



**Naveenkumar and Subramanian**

sustainable practices. The study's implications contribute to the body of knowledge on environmental management and policy, inform decision-making processes, and promote sustainable practices for the effective regulation of river pollution.

**Future suggestions for Research and Policy Development**

It is essential to address current issues such as household sewage, industrial effluents, plastic dumping, illicit sand mining, and encroachments in order to improve river pollution control in Tamil Nadu. The Tamil Nadu Pollution Control Board (TNPCB) should be given more authority to control pollution from various sources, and cooperation between various government organizations should be improved. To improve the pollution control board's monitoring mechanism, these organizations ought to send the board recurring reports. Future studies should concentrate on creating efficient policies and methods to protect Tamil Nadu's river basins as well as raising public knowledge of and participation in environmental conservation. The Tamil Nadu Pollution Control Board should also be changed into an independent government organization, much like the Indian Election Commission. Although the TNPCB has made strides in combating industrial pollution, it is constrained in its ability to address problems with home sewage and plastic dumping. The establishment of a dual government agency system is necessary to achieve effective pollution management. Collaboration between many parties is necessary, including other governmental entities like local organizations and the public works department. These joint initiatives will aid in more effective pollution control in river basins.

**CONCLUSION**

The enforcement of environmental regulations by the Tamil Nadu Pollution Control Board (TNPCB) faces several obstacles, as revealed in this study. While the TNPCB oversees pollution control regulations, other departments hold primary responsibility for addressing different environmental concerns. The study highlights that the TNPCB operates with limited staff and lacks authority over various forms of pollution, which poses a significant challenge. A crucial issue lies in the absence of a comprehensive framework for addressing all types of pollution in the river basin. The TNPCB acknowledges and abides by the directives of the National Green Tribunal (NGT), which greatly assists in their implementation efforts. However, the study identifies difficulties faced by the TNPCB in executing NGT directives. For instance, there are instances when local government agencies refuse to pay fines ordered by the NGT, leaving the TNPCB powerless to take punitive action against them. Enforcement becomes further complicated as small polluting dyeing enterprises often reopen in different locations simultaneously when the NGT initiates enforcement actions. These findings illustrate the challenges encountered by the TNPCB in river water conservation. They emphasize the need for comprehensive measures and enhanced coordination among various departments to effectively address pollution issues. The study sheds light on the complexities of enforcing environmental rules and highlights the importance of streamlining regulatory frameworks and strengthening cooperation between different stakeholders to overcome these challenges and ensure effective river water conservation efforts.

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**Naveenkumar and Subramanian**



[https://en.wikipedia.org/wiki/Kaveri\\_River\\_water\\_dispute](https://en.wikipedia.org/wiki/Kaveri_River_water_dispute)  
The Cauvery flows in southern Karnataka and then to Tamil Nadu



Source: Picture taken by Researcher  
Legal actions and penalties for non-compliance





## Interval-Valued Neutrosophic Hyper Soft Rough Sets

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### ABSTRACT

The primary aim of this work is to introduce a novel view, which is referred to as Interval neutrosophic hypersoft rough set. This suggests that the research is going to define and describe this new concept. The new concept, Interval neutrosophic hypersoft roughest, is described as a general of a previously established concept hold as Interval neutrosophic soft roughset. This indicates that the new concept builds upon or extends the existing concept. The novel of Interval neutrosophichy per soft roughest has not been reported in the literature. The Interval valued neutrosophichy per soft approximation space is presented with illustrative examples and some of its properties are established. Some directions for applications and future research in this area a real so indicated.

**Keywords:** Hypersoftsets, Interval neutrosophicsets, Interval neutrosophic softsets, Interval neutrosophichy per soft sets, Interval neutrosophichy per soft rough sets

### INTRODUCTION

The extension to hypersoft sets implies a further enhancement of the softest was discussed by F.Smarandache [4] in 2018. A.AlQuranetal. [1] denoted an approach to Neutrosophic soft rough set in 2019. Some basic operations on hyper soft sets is studied by A.Mujahidetal. [2]. H.Wangetal. [5] produced the interval neutrosophic sets. P.K.Maji[9] established some characteristics and properties on Neutrosophic softset. T.Y.Ozturketal.[13] have redefined operations on Neutrosophic softsets with illustrative examples.An aggregate operator on Neutrosophic hypersoft sets was studied by M.Saqlainetal.[8]. K.Huseyin[6] investigated on hybrid structure of hypersoft sets and roughsets. M.Dasetal.[7]expanded the roughset, softset, and Neutrosophic set by combining Neutrosophic softest with roughest







**Subha and Selvakumar**

theory. S.Broumi et al. [11,12] discussed a hybrid structure of rough neutrosophic set and its properties. A. Yolcu et al. [3] have broadened the scope of rough, soft and Neutrosophic sets by developing the Neutrosophic soft rough set. Xu, Dong-shen et al. [14] have proposed to the covering rough sets to interval neutrosophic sets. S. Broumi and F. Smarandache [10] have proposed for the interval neutrosophic soft rough sets and their properties. In this article, portion 2, studied with the necessary preliminaries. In portion 3, we present the definition of IVNHSS and give an example. Some characteristics of Interval valued Neutrosophic hyper soft approximation space is established.

**Preliminaries**

The necessary fundamental definitions such as interval neutrosophic set, hyper soft set, rough set, some properties of interval neutrosophic hyper soft set and interval neutrosophic hyper soft rough set can be found in [3, 10].

**Interval-Valued Neutrosophic Hyper soft Rough Sets**

As a generalisation of the interval neutrosophic soft rough sets, we presented an interval neutrosophic hyper soft rough set in this portion.

**Definition 3.1.** Let  $U$  be a non-empty universe set and  $P_{IVN}(U)$  be the set of all interval-valued neutrosophic sets over  $U$ . Let  $E$  denote the set of parameters. We assume that  $E = \{\Delta_1, \Delta_2, \dots, \Delta_n\}$  where  $\Delta_i \neq \Delta_j = \emptyset$  for  $i \neq j$ . Let  $\delta_j \subseteq \Delta_j$   $j \in \{1, 2, \dots, n\}$ . Then  $\delta_j \subseteq \Delta_j$ .

The pair  $(IVN, \prod_{j=1}^n \delta_j) = P_{IVNH}(U)$ , where  $IVN$  is mapping defined by  $IVN : \prod_{j=1}^n \delta_j \rightarrow P_{IVN}(U)$  is called a interval-valued neutrosophic hypersoft set (IVNHSS). The triplet  $(U, IVN, \prod_{j=1}^n \delta_j)$  is called a interval-valued neutrosophic hypersoft approximation space. The lower and upper interval-valued neutrosophic hypersoft approximation spaces of  $K \in P_{IVNH}(U)$  with respect to  $(U, IVN, \prod_{j=1}^n \delta_j)$  are denoted by  $\underline{apr}_{IVNHSS}(K)$  and  $\overline{apr}_{IVNHSS}(K)$  respectively, defined by

$$\underline{apr}_{IVNHSS}(K) = \left\{ \left( \prod_{j=1}^n \delta_j, \left\langle \frac{x}{\left[ \inf_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right], \left[ \inf_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right], \left[ \inf_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x) \right]} \right) \right\}, \forall x \in U$$

$$\overline{apr}_{IVNHSS}(K) = \left\{ \left( \prod_{j=1}^n \delta_j, \left\langle \frac{x}{\left[ \inf_{\overline{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\overline{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right], \left[ \inf_{\overline{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\overline{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right], \left[ \inf_{\overline{\omega}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\overline{\omega}_{\Pi_{j=1}^n \delta_j}}(x) \right]} \right) \right\}, \forall x \in U$$

Where,

$$\left[ \inf_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right] = \left\{ \left[ \wedge \inf_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \wedge \sup_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right] : \left[ \wedge \inf_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \wedge \sup_{\underline{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right] \in K \cap (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, \forall x \in U \right\}$$

$$\left[ \inf_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right] = \left\{ \left[ \wedge \inf_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \wedge \sup_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right] : \left[ \wedge \inf_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \wedge \sup_{\underline{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right] \in K \cap (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, \forall x \in U \right\}$$

$$\left[ \inf_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x) \right] = \left\{ \left[ \wedge \inf_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x), \wedge \sup_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x) \right] : \left[ \wedge \inf_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x), \wedge \sup_{\underline{\omega}_{\Pi_{j=1}^n \delta_j}}(x) \right] \in K \cap (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, \forall x \in U \right\}$$





**Subha and Selvakumar**

$$\begin{aligned}
 & \left[ \inf_{\bar{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right] \\
 &= \left\{ \left[ \inf_{\bar{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right] : \left[ \inf_{\bar{\mu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\mu}_{\Pi_{j=1}^n \delta_j}}(x) \right] \in K \cap (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, \forall x \in U \right\} \\
 & \left[ \inf_{\bar{\eta}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\eta}_{\Pi_{j=1}^n \delta_j}}(x) \right] \\
 &= \left\{ \left[ \inf_{\bar{\eta}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\eta}_{\Pi_{j=1}^n \delta_j}}(x) \right] : \left[ \inf_{\bar{\eta}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\eta}_{\Pi_{j=1}^n \delta_j}}(x) \right] \in K \cap (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, \forall x \in U \right\} \\
 & \left[ \inf_{\bar{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right] \\
 &= \left\{ \left[ \inf_{\bar{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right] : \left[ \inf_{\bar{\nu}_{\Pi_{j=1}^n \delta_j}}(x), \sup_{\bar{\nu}_{\Pi_{j=1}^n \delta_j}}(x) \right] \in K \cap (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, \forall x \in U \right\}
 \end{aligned}$$

Where “min” and “max” operators are denoted by “∧” and “∨” respectively. It is easy to see that by  $\underline{apr}_{IVNHSS}(K)$  and  $\overline{apr}_{IVNHSS}(K)$  is two IVNHSSs over  $P_{IVNH}(U)$ . It is said that  $K$  is an interval valued neutrosophic hypersoft definable set if  $\underline{apr}_{IVNHSS}(K) = \overline{apr}_{IVNHSS}(K)$ , otherwise it is referred to us an interval valued neutrosophic hypersoft rough sets (IVNHSSs).

**Example 3.2.** Let  $U = \{x_1, x_2, x_3, x_4\}$ . Define the attributes sets by,

$$\Delta_1 = \{e_{11}, e_{12}\}, \Delta_2 = \{e_{21}, e_{22}\}, \Delta_3 = \{e_{31}, e_{32}\}.$$

Let  $\delta_1 = \{e_{11}, e_{12}\}, \delta_2 = \{e_{21}, e_{22}\}, \delta_3 = \{e_{31}\}$  that is Let  $\prod_{j=1}^n \delta_j \subseteq \prod_{j=1}^n \Delta_j$   $j \in 1,2,3$ . Let the IVNHSS,

$$(IVN_1, \prod_{j=1}^3 \delta_j) = \left\{ \begin{aligned} & \left( (e_{11}, e_{21}, e_{31}), \left\{ \begin{aligned} & \left( \frac{x_1}{\langle [ .3, .5], [ .2, .6], [ .6, .9] \rangle}, \frac{x_2}{\langle [ .4, .7], [ .3, .7], [ .2, .9] \rangle} \right) \right\} \right), \\ & \left( (e_{13}, e_{23}, e_{33}), \left\{ \begin{aligned} & \left( \frac{x_1}{\langle [ .2, .7], [ .3, .5], [ .2, .6] \rangle}, \frac{x_2}{\langle [ .1, .3], [ .5, .7], [ .6, .9] \rangle} \right) \right\} \right), \\ & \left( \frac{x_3}{\langle [ .5, .7], [ .2, .6], [ .7, .9] \rangle} \right) \end{aligned} \right\} \right), \\ & \left( (e_{11}, e_{22}, e_{31}), \left\{ \begin{aligned} & \left( \frac{x_2}{\langle [ .2, .3], [ .4, .6], [ .5, .7] \rangle} \right) \right\} \right), \\ & \left( (e_{11}, e_{21}, e_{31}), \left\{ \begin{aligned} & \left( \frac{x_3}{\langle [ .8, .9], [ .5, .8], [ .5, .7] \rangle}, \frac{x_4}{\langle [ .1, .3], [ .3, .9], [ .6, .8] \rangle} \right) \right\} \right), \\ & \left( (e_{12}, e_{22}, e_{31}), \left\{ \begin{aligned} & \left( \frac{x_3}{\langle [ .4, .9], [ .3, .7], [ .4, .6] \rangle}, \frac{x_4}{\langle [ .7, .9], [ .1, .3], [ .6, .8] \rangle} \right) \right\} \right), \\ & \left( (e_{13}, e_{21}, e_{31}), \left\{ \begin{aligned} & \left( \frac{x_2}{\langle [ .3, .6], [ .7, .9], [ .2, .8] \rangle}, \frac{x_3}{\langle [ .3, .9], [ .1, .7], [ .3, .7] \rangle} \right) \right\} \right) \end{aligned} \right\} \right)
 \end{aligned} \right.$$

Let  $\alpha_1 = \{e_{11}\}, \alpha_2 = \{e_{21}, e_{22}\}, \alpha_3 = \{e_{31}, e_{32}\}$  that is Let  $\prod_{j=1}^n \alpha_j \subseteq \prod_{j=1}^n \Delta_j$   $j \in 1,2,3$ . Let the IVNHSS,





**Subha and Selvakumar**

$$(IVN_2, \prod_{j=1}^3 \alpha_j) = \left\{ \begin{array}{l} \left( (e_{11}, e_{21}, e_{31}), \left\{ \frac{x_2}{\langle [2, 4], [2, 6], [3, 5] \rangle}, \frac{x_3}{\langle [4, 9], [6, 8], [2, 4] \rangle} \right\} \right), \\ \left( (e_{13}, e_{23}, e_{33}), \left\{ \frac{x_2}{\langle [3, 6], [2, 8], [2, 4] \rangle}, \frac{x_3}{\langle [1, 3], [5, 8], [2, 8] \rangle} \right\} \right), \\ \left( (e_{11}, e_{22}, e_{31}), \left\{ \frac{x_2}{\langle [2, 8], [1, 5], [4, 8] \rangle} \right\} \right), \\ \left( (e_{11}, e_{21}, e_{32}), \left\{ \frac{x_1}{\langle [2, 3], [4, 6], [1, 3] \rangle}, \frac{x_4}{\langle [3, 5], [4, 8], [6, 8] \rangle} \right\} \right), \\ \left( (e_{11}, e_{22}, e_{32}), \left\{ \frac{x_3}{\langle [1, 2], [4, 6], [3, 8] \rangle}, \frac{x_4}{\langle [2, 5], [1, 5], [6, 8] \rangle} \right\} \right), \\ \left( (e_{13}, e_{21}, e_{31}), \left\{ \frac{x_2}{\langle [3, 6], [6, 8], [3, 4] \rangle}, \frac{x_3}{\langle [5, 9], [7, 8], [6, 9] \rangle} \right\} \right) \end{array} \right\}$$

Let  $\beta_1 = \{e_{11}, e_{12}\}$ ,  $\beta_2 = \{e_{21}, e_{22}\}$ ,  $\beta_3 = \{e_{31}\}$  that is Let  $\prod_{j=1}^n \beta_j \subseteq \prod_{j=1}^n \Delta_j$   
 $j \in 1, 2, 3$ . Let the IVNHSS,

$$(IVN_3, \prod_{j=1}^3 \beta_j) = \left\{ \begin{array}{l} \left( (e_{11}, e_{21}, e_{31}), \left\{ \frac{x_2}{\langle [2, 5], [3, 4], [2, 7] \rangle}, \frac{x_3}{\langle [5, 7], [8, 9], [4, 6] \rangle}, \frac{x_4}{\langle [1, 4], [6, 7], [3, 5] \rangle} \right\} \right), \\ \left( (e_{13}, e_{23}, e_{33}), \left\{ \frac{x_2}{\langle [2, 4], [6, 8], [2, 7] \rangle}, \frac{x_3}{\langle [5, 7], [2, 6], [7, 9] \rangle} \right\} \right), \\ \left( (e_{12}, e_{21}, e_{31}), \left\{ \frac{x_2}{\langle [4, 6], [7, 8], [2, 4] \rangle}, \frac{x_4}{\langle [3, 4], [1, 5], [6, 8] \rangle} \right\} \right), \\ \left( (e_{11}, e_{21}, e_{32}), \left\{ \frac{x_1}{\langle [7, 9], [2, 4], [6, 7] \rangle}, \frac{x_3}{\langle [6, 7], [3, 6], [3, 8] \rangle}, \frac{x_4}{\langle [6, 8], [2, 3], [1, 3] \rangle} \right\} \right), \\ \left( (e_{12}, e_{21}, e_{32}), \left\{ \frac{x_1}{\langle [1, 6], [3, 6], [6, 9] \rangle}, \frac{x_3}{\langle [8, 9], [3, 5], [6, 8] \rangle} \right\} \right), \\ \left( (e_{13}, e_{21}, e_{31}), \left\{ \frac{x_3}{\langle [2, 5], [5, 8], [8, 9] \rangle} \right\} \right) \end{array} \right\}$$





**Subha and Selvakumar**

Let K be an IVNHSS defined as

$$K = \left( \left( (e_{11}, e_{21}, e_{31}), \left\{ \begin{array}{l} \frac{x_1}{\langle [2, .5], [3, .6], [2, .6] \rangle} > \frac{x_2}{\langle [8, .9], [1, .3], [4, .6] \rangle} > \\ \frac{x_3}{\langle [3, .6], [2, .6], [3, .7] \rangle} > \frac{x_4}{\langle [3, .6], [1, .3], [8, .9] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{11}, e_{22}, e_{31}), \left\{ \frac{x_2}{\langle [4, .8], [4, .6], [4, .7] \rangle} \right\} \right), \right. \\ \left. \left( (e_{12}, e_{21}, e_{31}), \left\{ \begin{array}{l} \frac{x_2}{\langle [3, .5], [1, .3], [5, .6] \rangle} > \frac{x_3}{\langle [7, .9], [3, .8], [1, .6] \rangle} > \\ \frac{x_4}{\langle [3, .5], [2, .6], [2, .6] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{12}, e_{22}, e_{31}), \left\{ \begin{array}{l} \frac{x_1}{\langle [1, .4], [7, .9], [3, .6] \rangle} > \frac{x_4}{\langle [5, .7], [3, .6], [2, .8] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{11}, e_{21}, e_{32}), \left\{ \begin{array}{l} \frac{x_1}{\langle [2, .5], [3, .8], [5, .8] \rangle} > \frac{x_3}{\langle [5, .7], [7, .9], [4, .8] \rangle} > \\ \frac{x_4}{\langle [2, .6], [1, .6], [4, .8] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{11}, e_{22}, e_{32}), \left\{ \begin{array}{l} \frac{x_3}{\langle [7, .9], [3, .6], [3, .6] \rangle} > \frac{x_4}{\langle [2, .8], [1, .3], [4, .7] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{12}, e_{21}, e_{32}), \left\{ \begin{array}{l} \frac{x_1}{\langle [6, .7], [2, .4], [3, .5] \rangle} > \frac{x_3}{\langle [2, .4], [5, .7], [2, .8] \rangle} > \end{array} \right\} \right) \right)$$

Then the lower and upper IVNHSS approximation of K are calculated as

$$\underline{apr}_{IVNHSS}(K) = \left\{ \left( (e_{11}, e_{21}, e_{31}), \left\{ \frac{x_2}{\langle [2, .4], [1, .3], [2, .5] \rangle} \right\} \right) \right\}$$

$$\overline{apr}_{IVNHSS}(K) = \left( \left( (e_{11}, e_{21}, e_{31}), \left\{ \begin{array}{l} \frac{x_1}{\langle [3, .5], [3, .6], [2, .6] \rangle} > \frac{x_2}{\langle [8, .7], [3, .7], [2, .5] \rangle} > \\ \frac{x_3}{\langle [5, .9], [8, .9], [2, .6] \rangle} > \frac{x_4}{\langle [3, .6], [6, .7], [3, .5] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{11}, e_{22}, e_{31}), \left\{ \frac{x_2}{\langle [4, .6], [3, .6], [6, .8] \rangle} \right\} \right), \right. \\ \left. \left( (e_{12}, e_{21}, e_{31}), \left\{ \begin{array}{l} \frac{x_2}{\langle [4, .6], [7, .8], [2, .4] \rangle} > \frac{x_3}{\langle [8, .9], [5, .8], [1, .6] \rangle} > \\ \frac{x_4}{\langle [3, .5], [2, .6], [1, .6] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{12}, e_{22}, e_{31}), \left\{ \begin{array}{l} \frac{x_1}{\langle [4, .9], [7, .9], [3, .6] \rangle} > \frac{x_4}{\langle [7, .9], [3, .6], [2, .8] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{11}, e_{21}, e_{32}), \left\{ \begin{array}{l} \frac{x_1}{\langle [7, .9], [4, .8], [1, .3] \rangle} > \frac{x_3}{\langle [6, .7], [7, .9], [3, .8] \rangle} > \\ \frac{x_4}{\langle [6, .8], [4, .8], [1, .3] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{11}, e_{22}, e_{32}), \left\{ \begin{array}{l} \frac{x_3}{\langle [7, .9], [4, .6], [1, .3] \rangle} > \frac{x_4}{\langle [2, .8], [1, .5], [4, .7] \rangle} > \end{array} \right\} \right), \right. \\ \left. \left( (e_{12}, e_{21}, e_{32}), \left\{ \begin{array}{l} \frac{x_1}{\langle [6, .7], [3, .6], [3, .5] \rangle} > \frac{x_3}{\langle [8, .9], [5, .7], [2, .8] \rangle} > \end{array} \right\} \right) \right)$$







**Theorem 3.3.** Let  $(U, IVN, \prod_{j=1}^n \delta_j)$  be an interval valued neutrosophic hypersoft approximation space, and  $K, L \in P_{IVNH}(U)$ , then the following properties hold.

- i.  $\underline{apr}_{IVNHSS}(K) \subseteq K \subseteq \overline{apr}_{IVNHSS}(K)$
- ii.  $\underline{apr}_{IVNHSS}(K) \left( 0_{(U, \prod_{j=1}^n \delta_j)} \right) = 0_{(U, \prod_{j=1}^n \delta_j)}$   
 $\overline{apr}_{IVNHSS}(K) \left( 0_{(U, \prod_{j=1}^n \delta_j)} \right) = 0_{(U, \prod_{j=1}^n \delta_j)}$
- iii. If  $K \subseteq L$ , then  $\underline{apr}_{IVNHSS}(K) \subseteq \underline{apr}_{IVNHSS}(L)$
- iv. If  $K \subseteq L$ , then  $\overline{apr}_{IVNHSS}(K) \subseteq \overline{apr}_{IVNHSS}(L)$
- v.  $\underline{apr}_{IVNHSS}(K \cap L) \subseteq \underline{apr}_{IVNHSS}(K) \cap \underline{apr}_{IVNHSS}(L)$
- vi.  $\underline{apr}_{IVNHSS}(K \cup L) \subseteq \underline{apr}_{IVNHSS}(K) \cup \underline{apr}_{IVNHSS}(L)$
- vii.  $\overline{apr}_{IVNHSS}(K \cap L) \subseteq \overline{apr}_{IVNHSS}(K) \cap \overline{apr}_{IVNHSS}(L)$
- viii.  $\overline{apr}_{IVNHSS}(K \cup L) \subseteq \overline{apr}_{IVNHSS}(K) \cup \overline{apr}_{IVNHSS}(L)$

**Proof.**

- i. From the Definition 3.1., we can conclude that  $\underline{apr}_{IVNHSS}(K) \subseteq K$ .  
 In addition, from the definition of interval valued neutrosophic hypersoft upper approximation  $\forall K \cap (IVN_j, \prod_{j=1}^n \delta_j) \neq 0_{(U, \prod_{j=1}^n \delta_j)}$ ,  
 $[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)] \in K \cup (IVN_j, \prod_{j=1}^n \delta_j)$ . Hence  $K \subseteq \overline{apr}_{IVNHSS}(K)$ . Thus  $\underline{apr}_{IVNHSS}(K) \subseteq K \subseteq \overline{apr}_{IVNHSS}(K)$ .







**Subha and Selvakumar**

- ii. From Definition 3.1. the proof of (ii) naturally follows.
- iii. Let  $K \subseteq L$  and  $(IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, j = 1, 2, \dots, n$ . Then  $\underline{apr}_{IVNHSS}(K) = K \cap (\bigcap_{j=1}^n (IVN_j, \prod_{j=1}^n \delta_j))$ . Also, we have  $(IVN_j, \prod_{j=1}^n \delta_j) \subseteq K$  then  $(IVN_j, \prod_{j=1}^n \delta_j) \subseteq L$ . Hence  $\underline{apr}_{IVNHSS}(L) = L \cap (\bigcap_{j=1}^n (IVN_j, \prod_{j=1}^n \delta_j))$ . This implies  $\underline{apr}_{IVNHSS}(K) \subseteq \underline{apr}_{IVNHSS}(L)$ .
- iv. Let  $K \subseteq L$  and  $(IVN_j, \prod_{j=1}^n \delta_j) \subseteq K, j = 1, 2, \dots, n$ . Then  $\overline{apr}_{IVNHSS}(K) = K \cup (\bigcap_{j=1}^n (IVN_j, \prod_{j=1}^n \delta_j))$ . For  $\subseteq L$ , then  $(IVN_j, \prod_{j=1}^n \delta_j) \cap L \neq \emptyset$  and  $\overline{apr}_{IVNHSS}(L) = L \cup (\bigcap_{j=1}^n (IVN_j, \prod_{j=1}^n \delta_j))$ . This implies  $\overline{apr}_{IVNHSS}(K) \subseteq \overline{apr}_{IVNHSS}(L)$ .
- v. Let  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in \underline{apr}_{IVNHSS}(K \cap L)$ . There exist  $(IVN_j, \prod_{j=1}^n \delta_j)$  such that  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in (IVN_j, \prod_{j=1}^n \delta_j) \subseteq \underline{apr}_{IVNHSS}(K \cap L)$ ,  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in \underline{apr}_{IVNHSS}(K \cap L)$ ,  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in \underline{apr}_{IVNHSS}(K \cap L)$ ,  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K$  and  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in (IVN_j, \prod_{j=1}^n \delta_j) \subseteq L$ . Therefore  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in \underline{apr}_{IVNHSS}(K)$  and  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in \underline{apr}_{IVNHSS}(L)$ , implying  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in \underline{apr}_{IVNHSS}(K) \cap \underline{apr}_{IVNHSS}(L)$ . Thus  $\underline{apr}_{IVNHSS}(K \cap L) \subseteq \underline{apr}_{IVNHSS}(K) \cap \underline{apr}_{IVNHSS}(L)$ .
- vi. Let  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \notin \underline{apr}_{IVNHSS}(K \cap L)$ . There exist  $(IVN_j, \prod_{j=1}^n \delta_j)$  such that  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)]} \in (IVN_j, \prod_{j=1}^n \delta_j) \notin \underline{apr}_{IVNHSS}(K \cap L)$ , hence it follows that  $(IVN_j, \prod_{j=1}^n \delta_j) \not\subseteq K$  and  $\underline{apr}_{IVNHSS}(K \cap L) \not\subseteq \underline{apr}_{IVNHSS}(K) \cap \underline{apr}_{IVNHSS}(L)$ .





**Subha and Selvakumar**

$(IVN_j, \prod_{j=1}^n \delta_j) \notin L$ . There  
 fore  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \notin \underline{apr}_{IVNHSS}(K)$  and  
 $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \notin \underline{apr}_{IVNHSS}(L)$ , implying  
 $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in$   
 $\underline{apr}_{IVNHSS}(K) \cup \underline{apr}_{IVNHSS}(L)$ . Thus  
 $\underline{apr}_{IVNHSS}(K \cup L) \subseteq \underline{apr}_{IVNHSS}(K) \cup \underline{apr}_{IVNHSS}(L)$ .

vii. Let  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in \overline{apr}_{IVNHSS}(K \cap L)$ .  
 There exist  $(IVN_j, \prod_{j=1}^n \delta_j)$  such that

$x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in$   
 $(IVN_j, \prod_{j=1}^n \delta_j) \cap (K \cap L) \neq 0_{(U, \prod_{j=1}^n \delta_j)}$ ,  $(IVN_j, \prod_{j=1}^n \delta_j) \cap (K) \neq$   
 $0_{(U, \prod_{j=1}^n \delta_j)}$  and  $(IVN_j, \prod_{j=1}^n \delta_j) \cap (L) \neq 0_{(U, \prod_{j=1}^n \delta_j)}$ . There  
 fore  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in \overline{apr}_{IVNHSS}(K)$  and  
 $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in \overline{apr}_{IVNHSS}(L)$ , implying  
 $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in$   
 $\overline{apr}_{IVNHSS}(K) \cap \overline{apr}_{IVNHSS}(L)$ . Thus  
 $\overline{apr}_{IVNHSS}(K \cap L) \subseteq \overline{apr}_{IVNHSS}(K) \cap \overline{apr}_{IVNHSS}(L)$ .

viii. Let  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in \overline{apr}_{IVNHSS}(K \cup L)$ .  
 There exist  $(IVN_j, \prod_{j=1}^n \delta_j)$  such that

$x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in$   
 $(IVN_j, \prod_{j=1}^n \delta_j) \cap (K \cup L) \neq 0_{(U, \prod_{j=1}^n \delta_j)}$ , it follows  
 that  $(IVN_j, \prod_{j=1}^n \delta_j) \cap (K) \neq 0_{(U, \prod_{j=1}^n \delta_j)}$  or  $(IVN_j, \prod_{j=1}^n \delta_j) \cap (L) \neq$   
 $0_{(U, \prod_{j=1}^n \delta_j)}$ . There fore  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in$   
 $\overline{apr}_{IVNHSS}(K)$  or  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in$   
 $\overline{apr}_{IVNHSS}(L)$ . Hence  $x_{\prod_{j=1}^n \delta_j}^{[inf_{\bar{\mu}}(x), sup_{\bar{\mu}}(x)], [inf_{\bar{\eta}}(x), sup_{\bar{\eta}}(x)], [inf_{\bar{\nu}}(x), sup_{\bar{\nu}}(x)]} \in$   
 $\overline{apr}_{IVNHSS}(K) \cup \overline{apr}_{IVNHSS}(L)$ . Thus  
 $\overline{apr}_{IVNHSS}(K \cup L) \subseteq \overline{apr}_{IVNHSS}(K) \cup \overline{apr}_{IVNHSS}(L)$ .





**Theorem 3.3.** Let  $(U, IVN, \prod_{j=1}^n \delta_j)$  be an interval valued neutrosophic hypersoft approximation space, and  $K \in P_{IVNH}(U)$ , then the following properties hold.

- i.  $\underline{apr}_{IVNHSS}(\underline{apr}_{IVNHSS}(K)) = \underline{apr}_{IVNHSS}(K)$
- ii.  $\overline{apr}_{IVNHSS}(\overline{apr}_{IVNHSS}(K)) \supseteq \overline{apr}_{IVNHSS}(K)$
- iii.  $\overline{apr}_{IVNHSS}(K) \subseteq \overline{apr}_{IVNHSS}(\overline{apr}_{IVNHSS}(K))$
- iv.  $\overline{apr}_{IVNHSS}(\underline{apr}_{IVNHSS}(K)) \supseteq \underline{apr}_{IVNHSS}(K)$

**Proof:-**

- i. Let  $x_{\prod_{j=1}^n \delta_j} [inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)] \in \underline{apr}_{IVNHSS}(K)$ . Then we have

$x_{\prod_{j=1}^n \delta_j} [inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)] \in (IVN_j, \prod_{j=1}^n \delta_j) \subseteq \underline{apr}_{IVNHSS}(K)$ . So  $x_{\prod_{j=1}^n \delta_j} [inf_{\underline{\mu}}(x), sup_{\underline{\mu}}(x)], [inf_{\underline{\eta}}(x), sup_{\underline{\eta}}(x)], [inf_{\underline{\nu}}(x), sup_{\underline{\nu}}(x)] \in \underline{apr}_{IVNHSS}(\underline{apr}_{IVNHSS}(K))$ . Therefore  $\underline{apr}_{IVNHSS}(K) \subseteq \underline{apr}_{IVNHSS}(\underline{apr}_{IVNHSS}(K))$ . From the Theorem 3.3.  $\underline{apr}_{IVNHSS}(K) \subseteq K$  using (iii) of Theorem 3.3 we obtain  $\underline{apr}_{IVNHSS}(\underline{apr}_{IVNHSS}(K)) \subseteq \underline{apr}_{IVNHSS}(K)$ . Hence  $\underline{apr}_{IVNHSS}(\underline{apr}_{IVNHSS}(K)) = \underline{apr}_{IVNHSS}(K)$ .

- ii. Let  $P = \overline{apr}_{IVNHSS}(K)$ . Using property (i) of Theorem 3.3. we get  $P \subseteq \overline{apr}_{IVNHSS}(K)$ . Hence  $\overline{apr}_{IVNHSS}(\overline{apr}_{IVNHSS}(K)) \supseteq \overline{apr}_{IVNHSS}(K)$ .
- iii. Let  $P = \overline{apr}_{IVNHSS}(K)$ . Using property (i) of Theorem 3.3. we get  $\overline{apr}_{IVNHSS}(K) \subseteq P$ . Hence  $\overline{apr}_{IVNHSS}(K) \subseteq \overline{apr}_{IVNHSS}(\overline{apr}_{IVNHSS}(K))$ .
- iv. Let  $Q = \underline{apr}_{IVNHSS}(K)$ . Using property (i) of Theorem 3.3. we get  $\underline{apr}_{IVNHSS}(K) \supseteq Q$ . Hence  $\overline{apr}_{IVNHSS}(\underline{apr}_{IVNHSS}(K)) \supseteq \underline{apr}_{IVNHSS}(K)$ .







**Subha and Selvakumar**

**Remark 3.5.** Let  $(U, IVN, \prod_{j=1}^n \delta_j)$  be an interval valued neutrosophic hypersoft approximation space, and  $K, L \in P_{IVNH}(U)$ , then the following properties hold.

- i.  $\underline{apr}_{IVNHSS}(K^c) \neq [\overline{apr}_{IVNHSS}(K)]^c$
- ii.  $\overline{apr}_{IVNHSS}(K^c) \neq [\underline{apr}_{IVNHSS}(K)]^c$

**Denition 3.6.** Let  $(IVN_1, \prod_{j=1}^n \delta_j)$  and  $(IVN_2, \prod_{j=1}^n \delta_j)$  be two IVNHSSs over the same universe set U. Then " $(IVN_1, \prod_{j=1}^n \delta_j)$  difference  $(IVN_2, \prod_{j=1}^n \delta_j)$ " operation on them is denoted by  $(IVN_1 \setminus IVN_2, \prod_{j=1}^n \delta_j)$  and is defined by

$$(IVN_1 \setminus IVN_2, \prod_{j=1}^n \delta_j) = (IVN_1, \prod_{j=1}^n \delta_j) \cap (IVN_2, \prod_{j=1}^n \delta_j)^c$$

$$= \left\{ \prod_{j=1}^n \delta_j, < x, [1 - inf_{\mu}, 1 - sup_{\mu}]_{IVN_j, \prod_{j=1}^n \delta_j(x)}, [1 - inf_{\eta}, 1 - sup_{\eta}]_{IVN_j, \prod_{j=1}^n \delta_j(x)}, [1 - inf_{\nu}, 1 - sup_{\nu}]_{IVN_j, \prod_{j=1}^n \delta_j(x)} > : x \in U : \prod_{j=1}^n \delta_j \subseteq \prod_{j=1}^n \Delta_j \right\}.$$

Where

$$[inf_{\mu}, sup_{\mu}]_{IVN_1 \setminus IVN_2, \prod_{j=1}^n \delta_j}(x) = \min \left\{ [inf_{\mu}, sup_{\mu}]_{IVN_1, \prod_{j=1}^n \delta_j}(x), [inf_{\mu}, sup_{\mu}]_{IVN_2, \prod_{j=1}^n \delta_j}(x) \right\}$$

$$[inf_{\eta}, sup_{\eta}]_{IVN_1 \setminus IVN_2, \prod_{j=1}^n \delta_j}(x) = \min \left\{ [inf_{\eta}, sup_{\eta}]_{IVN_1, \prod_{j=1}^n \delta_j}(x), [inf_{\eta}, sup_{\eta}]_{IVN_2, \prod_{j=1}^n \delta_j}(x) \right\}$$

$$[inf_{\nu}, sup_{\nu}]_{IVN_1 \setminus IVN_2, \prod_{j=1}^n \delta_j}(x) = \max \left\{ [inf_{\nu}, sup_{\nu}]_{IVN_1, \prod_{j=1}^n \delta_j}(x), [inf_{\nu}, sup_{\nu}]_{IVN_2, \prod_{j=1}^n \delta_j}(x) \right\}$$

**Definition 3.7.** Let  $\underline{apr}_{IVNHSS}(K)$  and  $\overline{apr}_{IVNHSS}(K)$  be interval valued neutrosophic hypersoft lower and upper approximations of  $K \in P_{IVNH}(U)$  with respect to the interval neutrosophic hypersoft approximation space K, respectively. Then

$$pos_{IVNHSS}(K) = \underline{apr}_{IVNHSS}(K)$$

$$neg_{IVNHSS}(K) = (\overline{apr}_{IVNHSS}(K))^c$$

$$bnd_{IVNHSS}(K) = \overline{apr}_{IVNHSS}(K) \setminus \underline{apr}_{IVNHSS}(K)$$

are called the interval neutrosophic hypersoft positive region, interval neutrosophic hypersoft negative region and interval neutrosophic hypersoft boundary region of K, respectively.

**Theorem 3.9.** Let  $(U, IVN, \prod_{j=1}^n \delta_j)$  be an interval valued neutrosophic hypersoft approximation space, and  $K \in P_{IVNH}(U)$ , then the following properties hold.

- i.  $\underline{apr}_{IVNHSS}(K \setminus L) \subseteq \underline{apr}_{IVNHSS}(K) \setminus \underline{apr}_{IVNHSS}(L)$
- ii.  $\overline{apr}_{IVNHSS}(K \setminus L) \supseteq \overline{apr}_{IVNHSS}(K) \setminus \overline{apr}_{IVNHSS}(L)$ .





**Subha and Selvakumar**

**Proof:**

- i. Let  $x \in \underline{apr}_{IVNHSS}(K \setminus L)$ .  
 $x \in \underline{apr}_{IVNHSS}(K \setminus L)$  means  $x \in (IVN_j, \prod_{j=1}^n \delta_j)$  such that  
 $x \in \underline{apr}_{IVNHSS}(K \setminus L)$ .  $x \in (IVN_j, \prod_{j=1}^n \delta_j) \subseteq K$  and  $x \in (IVN_j, \prod_{j=1}^n \delta_j) \subseteq L^c$ , implying  
 $x \in \underline{apr}_{IVNHSS}(K) \setminus \underline{apr}_{IVNHSS}(L)$ . Thus  $\underline{apr}_{IVNHSS}(K \setminus L) \supseteq \underline{apr}_{IVNHSS}(K) \setminus \underline{apr}_{IVNHSS}(L)$ .
- ii. Similarly the proof of (i).

**CONCLUSION**

This article defines the interval valued neutrosophic hypersoft rough set by combining the notions three sets: interval valued neutrosophic set, hypersoft set, and rough set. The study of fundamental properties such as union, intersection, and complement are illustrated using examples. The lower and upper rough interval valued neutrosophic hypersoft approximations are then specified and validated. We propose to work on multi-attribute, multi-criteria decision making problems using the theoretical properties of interval valued neutrosophic hypersoft rough sets defined in this work as our future research direction.

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**Subha and Selvakumar**

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## A Cryptographic Method Applied on a Trigonometric Ratio using Laplace Transform

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### ABSTRACT

In this paper authors investigated a new cryptography scheme on a trigonometric ratio using Laplace transform. We have used Laplace transform tool for converting plain text to cipher text for secure transmission of data. Laplace transform is a widely used tool for encryption of data. Several techniques are available for decryption of data. Decryption technique is used for converting cipher text to plain text. Modular arithmetic is used by authors in the process of decryption, also concept of congruence is used for evaluation of data.

**Keywords:** Laplace Transform, Encryption, Decryption, Cryptography.

### INTRODUCTION

The insecure nature of channel signifies the importance of cryptography. Cryptography is an art of writing for securing the information float over an insecure channel. Camouflaging the message by a process called encryption involved camouflaging of plain text to ciphertext. Several techniques are developed and widely used for encrypting the data. One of them is done by the application of Laplace transform. Encryption is often carried out with the help of the key. The key can be a number or a number set and encryption well defined function transformation done on the plain text with the involvement of key. The secure communication process is called a cryptosystem. A cryptosystem consist of the set of possible plain text, the set of possible cipher text, the set of possible keys. Each key has a pair of rules  $E_k$  and  $D_k$ .  $E_k$  is an encryption rule to map plain text to cipher text,  $D_k$  is decryption rule to map cipher text to plain text.





**Rinku Verma et al.,**

Decryption is the reverse process. Decryption is carried out following the same algorithm as for encryption with the difference that the keys are used in the reverse order in the algorithm implementation. The process of breaking through the encryption decryption process is called cryptanalysis. Cryptanalyst analyze and interpret data and data patterns to decipher and generate enclosed signal. Several applications of cryptography includes banking transaction cards, computer passwords and e-commerce transaction. Laplace transform has a wide range of applications in various field and it is one of the important tool for converting plain text to cipher text. Taking the inverse laplace transform we can find the solution of the original problem. This concept was given by Hiwarekar A.P. (2012). Hiwarekar A.P. (2013) also proposed a Laplace Transform based text encryption algorithm . Kodathala S.V., et. al (2019) used the concept of Laplace Transform for encryption and Inverse Laplace Transform for decryption and also dynamically generated a key to reduce the risk of pirate of data. Lakshmi G.N., Kumar B.R., & Sekhar A.C. (2011) proposed a new cryptographic scheme using Laplace Transform to protect the secret messages from hackers. Gupta, P. and Mishra P.R. (2014) and Gencoglu M.T. (2017) explained that as the encryption method is independent of the Laplace Transform and ciphertext can be decrypted by elementary modular arithmetical arguments so it is a weak scheme. Nagalakshmi G., Sekhar A.C. & Sankar D.R. (2020) used public and private key to developed a asymmetric cryptography by using Laplace Transform and Inverse Laplace Transform on Maclaurin series and compare this algorithm with ElGamal and RSA cryptosystem. Tyagi N., et. al (2017) tried to modify the contemporary methods in order to reserved the intimate information by converting protection of key in private key cryptography. Although Laplace Transform is an important technique but Bodkhe D.S., & Panchal S.K. (2015) showed that without knowing the secret key the password can be broken by using Sumudu Transform based cryptosystems. Jagtap G.S. (2020) used the method of cryptography to tangent trigonometric functions by using Laplace Transform. Liu X.G.F., Lu B & Yang C. (2010) showed the application of proposed general attack scenario to conduct security analysis. Shivaji J.S. & Hiwarekar A.P. (2021) proposed a new method for cryptography by using Laplace-Elzaki Transform to increase the level of security. Vishwakarma M. (2013) studied the different classes of encryption algorithm and its application in data security.

**Preliminaries**

**Definition 1.1**

If  $f(t)$  is a function defined for all positive values of  $t$ , then the Laplace Transform of  $f(t)$  is defined as  $L\{f(t)\} = \int_0^\infty e^{-st} f(t)dt = F(s)$ , provided the integral converges. Here the parameter  $s$  is a real or complex number.

From the definition of Laplace transform we have,

$$L\{t^n\} = \frac{n!}{s^{n+1}}, \text{ for } n = 1, 2, 3, \dots$$

**Definition 1.2**

If  $L\{f(t)\} = F(s)$ , then  $f(t)$  is known as the Inverse Laplace Transform of  $F(s)$  and is denoted by  $L^{-1}\{F(s)\} = f(t)$ .

**Definition 1.3**

Let  $L\{f(t)\} = F(s)$  and  $L\{g(t)\} = G(s)$ , then

$$L\{c_1f(t) + c_2g(t)\} = c_1L\{f(t)\} + c_2L\{g(t)\}, \text{ where } c_1 \text{ and } c_2 \text{ are constants.}$$

**Numerical Assignment of Letters**

A	B	C	...	Y	Z
0	1	2	...	24	25

**Encryption Algorithm**

Step 1: Sender and receiver agrees on a key.

Step 2: The series explore to solve the problem is:

$$t^n \sin rt = rt^{n+1} - \frac{r^3 t^{n+3}}{3!} + \frac{r^5 t^{n+5}}{5!} - \frac{r^7 t^{n+7}}{7!} + \dots = \sum_{i=0}^{\infty} \frac{r^{2i+1} t^{2i+n+1} (-1)^i}{(2i+1)!}$$

Step 3: Allocate numbers to alphabets to determine equivalent plain text. Represent each term as  $G_i ; i \geq 0$ .

Step 4: Each  $G_i$  is considered as coefficient of  $t^n \sin rt$ .

Step 5: Consider the number of terms of the series as much as  $G_i$  you get.

Step 6: For  $G_n ; n = 2i + 1 ; i \geq 0$ ; convert it in to its equivalent  $H_n$  using  $G_n \equiv H_n \pmod{26}$ .

Step 7: Find Laplace transform of the given series using  $\{t^n\} = \frac{n!}{s^{n+1}}$ .





**Rinku Verma et al.,**

Step 8: The resulting coefficients if greater than or equals to 25 are solved using congruence relation as  $a \equiv b \pmod{n}$ .

Step 9: Sender sends the values which are quotients in the mode operation as a key.

Step 10: In the resulting key if terms are  $\geq 25$  use congruence relation to find the cipher text. Represent the terms of ciphertext as  $l_i$ .

**Decryption Algorithm**

$$\begin{aligned} \text{Step 1: } L &= \left[ \sum_{i=0}^{\infty} \frac{r^{2i+1} t^{2i+n+1} (-1)^i G_i}{(2i+1)!} \right] \\ &= L \left[ \sum_{i=0,2,4,\dots}^{\infty} \frac{r^{2i+1} t^{2i+n+1} G_i}{(2i+1)!} \right] + L \left[ \sum_{i=1,3,5,\dots}^{\infty} \frac{r^{2i+1} t^{2i+n+1} H_i}{(2i+1)!} \right]; H_i = -G_i \\ &= \sum_{i=0,2,4,\dots}^{\infty} \frac{r^{2i+1} (2i+n+1)! G_i}{(2i+1)! S^{2i+n+2}} + \sum_{i=1,3,5,\dots}^{\infty} \frac{r^{2i+1} (2i+n+1)! H_i}{(2i+1)! S^{2i+n+2}} \end{aligned}$$

Step 2: If each  $G_i \leq 25$

find

$$r^{2i+1} (2i+n+1) (2i+n) \dots (2i+2) G_i = 26k_i + l_i \text{ for } i = 0, 2, 4, \dots \text{ for first series.}$$

$$\text{And } r^{2i+1} (2i+n+1) (2i+n) \dots (2i+2) H_i = 26k_i + l_i \text{ for } i = 1, 3, 5, \dots \text{ for second series.}$$

Else use concept of congruence.

Step 3: Consider  $G_{i,j}$  for  $k_i$  and  $26 - H_{i,j}$  for  $k_i$  which satisfies the values with the key values sender sends, if required use the concept of congruence.

Above algorithm is explained using the following example

Given plain text "STRANGE" is equivalent to 18 19 17 0 13 6 4.

The series explore to solve the problem is

$$t^n \sin rt = t^n \left[ rt - \frac{(rt)^3}{3!} + \frac{(rt)^5}{5!} - \frac{(rt)^7}{7!} + \dots \right] = \sum_{i=0}^{\infty} \frac{(-1)^i (r)^{2i+1} (t)^{2i+n+1}}{(2i+1)!}$$

Where  $r, n \in \mathbb{N}$  is a constant.

Take  $r = 2, n = 2,$

$$\text{So, } t^2 \sin 2t = 2t^3 - \frac{2^3 t^5}{3!} + \frac{2^5 t^7}{5!} - \frac{2^7 t^9}{7!} + \dots = \sum_{i=0}^{\infty} \frac{(-1)^i (2)^{2i+3} (t)^{2i+5}}{(2i+1)!}$$

Neglect higher order terms as per requirement.

Recognizing coefficients as  $G_0 = 18, G_1 = 19, G_2 = 17, G_3 = 0, G_4 = 13, G_5 = 6, G_6 = 4.$

Writing these numbers as coefficient of the series  $t^2 \sin 2t$  assuming  $f(t) = G_i t^2 \sin 2t$ .

We get,

$$f(t) = G_0 2t^3 - G_1 \frac{2^3 t^5}{3!} + G_2 \frac{2^5 t^7}{5!} - G_3 \frac{2^7 t^9}{7!} + G_4 \frac{2^9 t^{11}}{9!} - G_5 \frac{2^{11} t^{13}}{11!} + G_6 \frac{2^{13} t^{15}}{13!}$$

Solve alternating (negative) terms of the series using congruence property that,  $a \equiv b \pmod{26}$ .

We get,

$$f(t) = 18(2t^3) + 7 \frac{2^3 t^5}{3!} + 17 \frac{2^5 t^7}{5!} + 0 \frac{2^7 t^9}{7!} + 13 \frac{2^9 t^{11}}{9!} + 20 \frac{2^{11} t^{13}}{11!} + 4 \frac{2^{13} t^{15}}{13!}$$

Taking Laplace Transform on both sides, we get,

$$L\{f(t)\} = 36 \frac{3!}{s^4} + 56 \frac{5!}{3! s^6} + 544 \frac{7!}{5! s^8} + 0 \frac{9!}{7! s^{10}} + 6656 \frac{11!}{9! s^{12}} + 40960 \frac{13!}{11! s^{14}} + 32768 \frac{15!}{13! s^{16}}$$

$$L\{f(t)\} = \frac{216}{s^4} + \frac{1120}{s^6} + \frac{22848}{s^8} + \frac{0}{s^{10}} + \frac{732160}{s^{12}} + \frac{6389760}{s^{14}} + \frac{6881280}{s^{16}}$$

Using concept of congruence we have,

$$216 \equiv 8 \pmod{26}, \quad 1120 \equiv 2 \pmod{26}, \quad 22848 \equiv 20 \pmod{26}, \quad 0 \equiv 0 \pmod{26}, \quad 732160 \equiv 0 \pmod{26}, \quad 6389760 \equiv 0 \pmod{26} \text{ and } 6881280 \equiv 16 \pmod{26}.$$

Representing them as  $l_i$ .

$l_1$	$l_2$	$l_3$	$l_4$	$l_5$	$l_6$	$l_7$
8	2	20	0	0	0	16
I	C	U	A	A	A	Q





**Rinku Verma et al.,**

Sender sends the values ( these are quotients in mode operation)

8 43 878 0 28160 245760 264664

$$L\{f(t)\} = G_0 \frac{2.3!}{1!5^4} + H_1 \frac{2^3.5!}{3!5^6} + G_2 \frac{2^5.7!}{5!5^8} + H_3 \frac{2^7.9!}{7!5^{10}} + G_4 \frac{2^9.11!}{9!5^{12}} + H_5 \frac{2^{11}.13!}{11!5^{14}} + G_6 \frac{2^{13}.15!}{13!5^{16}}$$

Since  $G_i \leq 25$  and numbers have equivalent in mod 26 we get

$$G_0.12 = 26.k_0 + 8 \Rightarrow G_0 = \frac{26.k_0+8}{12} \Rightarrow \begin{cases} k_0 = 2 \text{ for } G_{0,1} = 5 \\ k_0 = 8 \text{ for } G_{0,2} = 18 \end{cases}$$

$$H_1.160 = 26.k_1 + 2 \Rightarrow H_1 = \frac{26.k_1+2}{160} \Rightarrow \begin{cases} k_1 = 43 \text{ for } H_{1,1} = 7 \\ k_1 = 123 \text{ for } H_{1,2} = 20 \end{cases}$$

$$G_2.1344 = 26.k_2 + 20 \Rightarrow G_2 = \frac{26.k_2+20}{1344} \Rightarrow \begin{cases} k_2 = 206 \text{ for } G_{2,1} = 4 \\ k_2 = 878 \text{ for } G_{2,2} = 17 \end{cases}$$

$$H_3.9216 = 26.k_3 + 0 \Rightarrow H_3 = \frac{26.k_3+0}{9216} \Rightarrow \begin{cases} k_3 = 0 \text{ for } H_{3,1} = 0 \\ k_3 = 4608 \text{ for } H_{3,2} = 13 \end{cases}$$

$$G_4.56320 = 26.k_4 + 0 \Rightarrow G_4 = \frac{26.k_4+0}{56320} \Rightarrow \begin{cases} k_4 = 0 \text{ for } G_{4,1} = 0 \\ k_4 = 28160 \text{ for } G_{4,2} = 13 \end{cases}$$

$$H_5.319488 = 26.k_5 + 0 \Rightarrow H_5 = \frac{26.k_5+0}{319488} \Rightarrow \begin{cases} k_5 = 0 & \text{for } H_{5,1} = 0 \\ k_5 = 12288 & \text{for } H_{5,2} = 1 \\ k_5 = 24576 & \text{for } H_{5,3} = 2 \\ k_5 = 36864 & \text{for } H_{5,4} = 3 \\ k_5 = 49152 & \text{for } H_{5,5} = 4 \\ k_5 = 61440 & \text{for } H_{5,6} = 5 \\ k_5 = 73728 & \text{for } H_{5,7} = 6 \\ k_5 = 86016 & \text{for } H_{5,8} = 7 \\ k_5 = 98304 & \text{for } H_{5,9} = 8 \\ k_5 = 110592 & \text{for } H_{5,10} = 9 \\ k_5 = 122880 & \text{for } H_{5,11} = 10 \\ k_5 = 135168 & \text{for } H_{5,12} = 11 \\ k_5 = 147456 & \text{for } H_{5,13} = 12 \\ k_5 = 159744 & \text{for } H_{5,14} = 13 \\ k_5 = 172032 & \text{for } H_{5,15} = 14 \\ k_5 = 184320 & \text{for } H_{5,16} = 15 \\ k_5 = 196608 & \text{for } H_{5,17} = 16 \\ k_5 = 208896 & \text{for } H_{5,18} = 17 \\ k_5 = 221184 & \text{for } H_{5,19} = 18 \\ k_5 = 233472 & \text{for } H_{5,20} = 19 \\ k_5 = 245760 & \text{for } H_{5,21} = 20 \\ k_5 = 258048 & \text{for } H_{5,22} = 21 \\ k_5 = 270336 & \text{for } H_{5,23} = 22 \\ k_5 = 282624 & \text{for } H_{5,24} = 23 \\ k_5 = 294912 & \text{for } H_{5,25} = 24 \\ k_5 = 307200 & \text{for } H_{5,26} = 25 \end{cases}$$

$$G_6.1720320 = 26.k_6 + 16 \Rightarrow G_6 = \frac{26.k_6+16}{1720320} \Rightarrow \begin{cases} k_6 = 264664 & \text{for } G_{6,1} = 4 \\ k_6 = 1124824 & \text{for } G_{6,2} = 17 \end{cases}$$

So the given cipher text is equivalent to

18	19	17	0	13	6	4
S	T	R	A	N	G	E





**Rinku Verma et al.,**

## CONCLUSION

Using trigonometric ratio and applying the concept of Laplace transform a secured way of transmission of data can be performed. Similar concept can be used for other ratios or series is an open area of research.

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## Hybrid Precoding and Channel Estimation form Wave MIMO OFDM System

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### ABSTRACT

This paper presents a comprehensive study on channel estimation and hybrid precoding techniques in millimeter-wave (mmWave) multiple-input, multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM) systems. The unique characteristics of mmWave communication, such as severe path loss and atmospheric absorption, make accurate channel estimation imperative. The proposed channel estimation methods aim to achieve reliable channel state information (CSI) estimation under challenging conditions, improving system performance. Furthermore, the paper explores the benefits of hybrid precoding to exploit spatial degrees of freedom in MIMO systems, particularly in mmWave frequencies with large antenna arrays. The hybrid precoding combines analog and digital precoders to efficiently beamform signals, mitigating channel impairments and enhancing communication reliability. The results show that the proposed solutions are more effective and efficient than the existing methods while demonstrating design tradeoffs, spectral efficiency and sum rate.

**Keywords:** Millimeter wave, MIMO, hybrid precoding, OFDM, antenna arrays, frequency-selective channels, phase shifters.





## INTRODUCTION

Channel estimation and hybrid precoding are two important techniques used in mmWave MIMO OFDM systems. In this type of system, the use of multiple antennas and high carrier frequencies enable high data rates, but also present significant challenges in terms of channel estimation and beamforming. Channel estimation refers to the process of estimating the characteristics of a communication channel, which is the medium through which a signal reaches the receiver after leaving the source. In wireless communication systems, channel estimation is necessary because the channel characteristics can change over time and can affect the quality of a received signal. The receiver measures the received signal and uses this information to estimate the characteristics of the channel, such as the attenuation and delay of the signal. There are several techniques for channel estimation, including least squares estimation, maximum likelihood estimation, and Kalman filtering [1]. These methods estimate the channel based on the signal received using mathematical algorithms. Many wireless communication systems, including cellular networks, Wi-Fi, and satellite communications, rely heavily on channel estimate. Accurate channel estimation can improve the quality and reliability of the wireless communication system by allowing receiver to adjust its decoding algorithms based on the estimated channel characteristics. Hybrid precoding Hybrid precoding is a technique used in massive MIMO systems, those are wireless communication systems that employ a significant number of antennas at the transmitter and receiver to enhance system performance. [1]. Hybrid precoding is used to decrease the precoding complexity, which is the process of optimizing the transmit beamforming at the transmitter to improve the signal quality at the receiver. In a massive MIMO system with a more antennas, precoding can be computationally intensive and may not be feasible to implement in real-time. Hybrid precoding involves dividing the transmit precoding process into two stages: digital precoding and analog precoding. In digital precoding, the data to be transmitted is processed using digital signal processing techniques to generate a set of signals that are to be transmitted. In analog precoding, the signals are then processed using analog techniques, such as phase shifters, to create a set of analog waveforms that are transmitted by the antenna array. The advantage of hybrid precoding is that it reduces the complexity of the precoding process by separating it into two stages [2].

The digital precoding stage can be performed using low- complexity algorithms that can be implemented in real-time, while the analog precoding stage can be performed using simple and low-cost analog components. Hybrid precoding one of the important technique for implementing massive MIMO in practical wireless communication applications. By reducing the complexity of precoding, hybrid precoding enables the implementation of high-performance wireless communication systems with many antennas. Millimeter wave (mmWave) refers to a range of radio frequencies that fall between 30 GHz and 300 GHz. In wireless communication systems, mmWave is used to transmit data over short distances at high speeds. mmWave has several advantages over lower frequency bands. One advantage is that it can provide higher data rates because it has a larger bandwidth available for transmission. Another advantage is that it is less susceptible to interference from other wireless signals because it uses directional antennas that focus the signal in a specific direction. mmWave technology is used in several applications, including 5G cellular networks, Wi-Fi, and wireless backhaul. However, mmWave signals have limited range and are easily blocked by obstacles such as walls and buildings [2].

Therefore, mmWave systems typically require many small antennas and it use of beamforming techniques to maintain a strong and reliable connection. There are several obstacles preventing the general use of mmWave technology, which is still in its early phases of development. These challenges include the high cost of the equipment, the need for new infrastructure, and the limited range of mmWave signals. Nonetheless, mmWave technology is to play a significant role in the upcoming wireless communication system due to its potential for providing high-speed data transfer over short distances. Multiple Input Multiple Output, or MIMO, is a term used to describe a particular class of wireless communication system that makes use of multiple antennas at both the transmitter and the receiver to enhance the performance of the communication link. In MIMO, multiple streams of data can be transmitted and received simultaneously through different antenna paths, which allows for a higher data rate and improved





**Jagadeesh Chandra Prasad et al.,**

reliability. The system can also take advantage of the different paths to reduce interference and increase the range of the wireless communication. Modern wireless communication technologies including Wi-Fi, 4G and 5G cellular networks, and Bluetooth frequently employ MIMO systems. They can also be used in other applications such as radar and imaging systems. The capacity of a MIMO system—the most data that can be transferred over the channel—is often used to assess the system's performance [3]. A MIMO system's capacity is influenced by various elements, including the number of antennas, their spacing, and the properties of the wireless channel.

Modern wireless communication systems, including Wi-Fi digital television, and 4G LTE, use OFDM (Orthogonal Frequency Division Multiplexing) as a modulation technique to transfer data over a channel. The available bandwidth is split into several orthogonal narrowband subcarriers by OFDM. This means that the subcarriers can be transmitted simultaneously without interfering with one another because they do not interfere with one another. In an OFDM system, the data to be transmitted is divided into multiple symbols, each of which is mapped onto a set of subcarriers using a modulation scheme, such as QPSK or 16-QAM. The subcarriers are then modulated with the symbols and combined to form the OFDM signal, which is transmitted over the channel. At the receiver end, the OFDM signal is demodulated and the symbols are extracted from each subcarrier using FFT (Fast Fourier Transform). The symbols are then combined to reconstruct the original data. OFDM has several advantages over other modulation techniques. It can provide high data rates, is resistant to multipath fading, and can support multiple users by assigning different subcarriers to each user. However, OFDM also requires complex synchronization and channel estimation techniques to ensure reliable transmission over the channel.

## LITERATURE SURVEY

A hybrid precoder and combiner architecture using low-resolution phase shifters is put forth by Y. C. Liang et al. [9] for millimeter-wave (mmWave) multiple-input multiple-output (MIMO) systems. Substantial data speeds are possible with mmWave MIMO systems, but they also have substantial route loss and are sensitive to obstructions [3]. By using low-resolution phase shifters and fewer radio frequency (RF) chains than are typically needed, the suggested hybrid designs try to address these issues while retaining system performance. In order to show the usefulness of the suggested design in terms of spectrum efficiency and error rate performance, the article includes simulation data. Alkhateeb et al. [10] propose a low-complexity algorithm for estimating the channel at the base station using fewer measurements than the number of antennas. The algorithm employs the structured sparsity property of mmWave channels, which can be modeled as a sum of a few sparse vectors. The proposed algorithm achieves near-optimal estimation performance with a low number of measurements.

Alrabeiah and Jornet [4] propose a fast channel estimation technique for millimeter wave communication systems that use hybrid precoding. The proposed technique employs a compressive sensing-based method that exploits the sparsity of the channel in the angular domain. The authors demonstrate that the proposed technique achieves accurate channel estimation with fewer training symbols than conventional techniques, making it particularly well-suited for millimeter wave systems with limited training resources. Rusu et al. [11] proposed algorithm utilizes the hierarchical codebook design for precoder and combiner matrices. This algorithm is shown to have a low complexity in terms of the number of RF chains required for hybrid precoding, which can be a crucial factor for practical implementation of mmWave systems. H. Zhang, S. Yan, and Z. Ding [5] proposed a channel estimation method for millimeter-wave MIMO systems with one-bit quantization, and it shows that the proposed method outperforms several existing methods in terms of mean squared error and bit error rate. Xiong et al. [12] propose a joint beamforming and channel estimation approach for massive MIMO systems that employ low-resolution analog-to-digital converters (ADCs). The authors propose a new channel estimator based on a polynomial expansion of the channel matrix that can be computed efficiently and accurately even with low-resolution ADCs. In the final analysis, a well-liked method for addressing the rising demand for high-speed wireless communication is the employment of



**Jagadeesh Chandra Prasad et al.,**

multiple-input multiple-output (MIMO) techniques in combination with orthogonal frequency-division multiplexing (OFDM). Millimeter-wave (mmWave) MIMO systems must overcome difficulties such as high path loss and susceptibility to obstructions. Researchers have suggested several channel estimation and hybrid precoding strategies to overcome these issues. Several low-complexity hybrid precoding methods, such as low-resolution phase shifters and hierarchical codebook designs, have been put forth. Overall, taking into account all of these methods, the proposed method aims to maintain the functionality of mmWave MIMO OFDM systems while resolving the problems brought on by high path loss and obstructions. The simulation results shown in the research show how well the suggested strategies perform in terms of spectrum efficiency and error rate.

**EXISTING SYSTEM**

In multiple-input multiple-output (MIMO) system for millimeter-wave (mmWave) technology, hybrid beamforming is a promising method that lowers the quantity of radio frequency (RF) chains and power consumption. High-resolution phase shifters for hybrid beamforming can be expensive and problematic to build, albeit [3]. Low-resolution phase shifters can be employed to solve this problem, although they may degrade performance. A difficult difficulty in this situation is the design of hybrid precoders and combiners with low-resolution phase shifters. The optimisation of hybrid precoder and combiner designs for mmWave MIMO systems employing low-resolution phase shifters is the subject of this discussion. Utilising the spatial domain of the wireless channel, hybrid precoder and combiner design is a technique used in MIMO wireless communication systems to increase the efficiency of data transmission.

To boost the data throughput and spectral efficiency in MIMO systems, multiple antennas are employed on both the transmitter and reception sides. Typically, a matrix is used to represent the wireless channel between the transmitter and receiver, with each element representing the channel coefficient between a particular transmitter-receiver antenna pair. A method called hybrid precoding and combining lowers the number of radio frequency (RF) chains required for signal transmission and reception, which can simplify hardware and use less power [3]. precoding and combining, the channel matrix is decomposed into two matrices, a digital baseband matrix and an analog RF matrix. The digital baseband matrix is designed in the digital domain and applies phase shifts to the signals that will be transmitted or received.

The analog RF matrix applies beamforming to the phase-shifted signals in the analog domain, using an array phase-shifted signals in the analog domain, using an array combiner design is to optimize the digital and analog matrices to maximize the signal quality, data rate, or other performance metrics while considering hardware and computational constraints. One-bit resolution analog precoder and combiner design

Wireless communication systems use the one-bit resolution analogue precoder and combiner design technique to streamline analogue signal processing and lessen the complexity of the hardware. This technique involves the use of simple circuits to perform the analog precoding and combining operations with only one bit of resolution, instead of using multiple bits as in traditional analog signal processing. It has been demonstrated that one-bit resolution analogue precoder and combiner designs function well in some situations, particularly gigantic MIMO systems where there are a lot of antennae [3]. Here, the emphasis is mostly on the construction of analogue precoders and combiners employing "one-bit" resolution (binary) PSs, which can minimise power consumption and simplify the hardware complexity to achieve maximum hardware efficiency. Although the iterative phase matching algorithm can also be used, the one-bit example allows for a more straightforward approach. Consequently, an effective analogue beamformer architecture with a one-bit resolution can produce good performance with substantially less complexity. To find the  $l$ -th analogue precoder and combiner pair, the suggested hybrid beamforming approach merely modifies the optimization problem. With the restriction of one-bit resolution PSs, we reformulate this analogue beamformer design problem specifically as







$$\begin{aligned} & \{ \mathbf{a}_{RF,l}^*, \mathbf{b}_{RF,l}^* \} \\ & = \operatorname{argmax} \begin{cases} \mathbf{a}_{RF,l} \in \frac{1}{\sqrt{NO_t}} \{ \pm 1 \}^{NO_t} \\ \mathbf{b}_{RF,l} \in \frac{1}{\sqrt{NO_r}} \{ \pm 1 \}^{NO_r} \end{cases} | \mathbf{b}_{RF,l}^H \mathbf{O}_l \mathbf{a}_{RF,l} | \end{aligned}$$

The interference included channel matrix  $\mathbf{O}_l$  is low-rank because the mmWave MIMO channel is sparse in the angular domain, which also contributes to its low-rank property. As a result, the rank-1 approximation offers a suitable and practical trade-off between algorithm complexity and performance.  $\mathbf{O}_l$  will typically have a rank larger than one, but we have discovered that the rank-1 approximation effectively covers the majority of instances and, more significantly, results in a considerably simpler solution.

Rank-1 approximation involves representing a matrix as a product of a column vector and a row vector, which greatly simplifies the matrix's structure. While the approximation may not be as accurate as the original matrix, it can still provide meaningful insights and results, and can be particularly useful for data compression, signal processing, and machine learning.

$$\begin{aligned} \mathbf{a}_{RF,l}^* & = \operatorname{argmax} \left\{ \mathbf{a}_{RF,l} \in \frac{1}{\sqrt{NO_t}} \{ \pm 1 \}^{NO_t} \right\} | \mathbf{a}_{RF,l}^H \mathbf{k}_{l,1} | \\ \mathbf{b}_{RF,l}^* & = \operatorname{argmax} \left\{ \mathbf{b}_{RF,l} \in \frac{1}{\sqrt{NO_r}} \{ \pm 1 \}^{NO_r} \right\} | \mathbf{b}_{RF,l}^H \mathbf{c}_{l,1} | \end{aligned}$$

So, that the complexity can be further reduced without suffering too much performance loss. As suggested, one can create a set of candidate beamformers with a smaller dimension from which one can find the ideal one with quadratic complexity. We will outline this algorithm for the precoder design in the sections that follow.

$$\begin{aligned} & \{ \emptyset^*, \mathbf{a}_{RF,l}^* \} \\ & = \operatorname{argmax} \begin{cases} \emptyset \in [-\pi \ \pi) \\ \mathbf{a}_{RF,l} \in \frac{1}{\sqrt{NO_t}} \{ \pm 1 \}^{NO_t} \end{cases} \Re \{ \mathbf{a}_{RF,l}^H \mathbf{k}_{l,1} e^{-j\emptyset} \} \\ & = \operatorname{argmax} \begin{cases} \emptyset \in [-\pi \ \pi) \\ \mathbf{a}_{RF,l} \in \frac{1}{\sqrt{NO_t}} \{ \pm 1 \}^{NO_t} \end{cases} \sum_{i=1}^{NO_t} \mathbf{a}_{RF,l}^H(i) | \mathbf{k}_{l,1}(i) | \cos(\emptyset - \psi_i) \end{aligned}$$

Here  $\psi_i$  represents phase of  $\mathbf{k}_{l,1}(i)$ , and it gave  $\emptyset \in [-\pi \ \pi)$  the optimal binary precoder for the relevant data is

$$\mathbf{a}_{RF,l}(i) = \frac{1}{\sqrt{NO_t}} \operatorname{sign}(\cos(\emptyset - \psi_i)), \quad i = 1, 2, \dots, NO_t$$

We will now demonstrate that, for every given situation, we can always create a collection of  $N_t$  potential binary precoders using the conditionally optimal  $\mathbf{a}_{RF,l}$  presented in. The fundamental issue with the design of hybrid





**Jagadeesh Chandra Prasad et al.,**

precoders and combiners for mmWave MIMO systems using low-resolution quantized phase shifters is that the system's performance can suffer dramatically in comparison to systems using high-resolution phase shifters.

This is because low-resolution phase shifters can only approximate the required phase shifts and introduce errors in the beamforming process, leading to reduced signal quality, beamforming gain, and interference suppression. Additionally, the design of low-resolution phase shifters for mmWave frequencies can be challenging, as the phase shift error increases with frequency and can result in further performance degradation [8]. For mmWave MIMO systems with low-resolution quantized phase shifters, the problem of hybrid precoder and combiner design necessitates careful consideration of a number of aspects,

including the system performance requirements. For mmWave MIMO systems with low-resolution quantized phase shifters, the issue of hybrid precoder and combiner design can be solved using a number of methods, including phase quantization, optimisation algorithms, channel estimation, calibration, and adaptive Beamforming.

## PROPOSED SYSTEM

### CHANNEL ESTIMATION AND HYBRID PRECODING FOR mmWAVE MIMO OFDM SYSTEMS

#### A. Point-to-Point mm Wave MIMO System Model

Modern communication systems heavily rely on the multiple-input multiple-output orthogonal frequency division multiplexing technology. To get the most out of the system, a low-resolution phase shifters precoding technique has been proposed. A low-resolution phase shifter is used to apply a phase shift to the signal at the transmitter before transmitting it over multiple antennas. The goal is to shape the signal so that it has a specific radiation pattern that is desirable for the application. The phase shifters in this technique have fewer bits of resolution compared to traditional high-resolution phase shifters. The low resolution of the phase shifters reduces the cost and power consumption of the system, but it can also reduce the precision of the beamforming. Despite the reduction in precision, low-resolution phase shifters can still provide significant performance improvements in the system. The design of hybrid precoders and combiners is implemented using the low-resolution phase shifter precoding technique as of the following. Low-resolution phase shifters precoding technique is used in various wireless communication systems, such as 5G, millimeter-wave communication, and satellite communication systems, where cost and power consumption are critical design factors [7]. This technique allows for an efficient and cost-effective way to implement beamforming in a communication system while still achieving significant performance improvements. As shown in figure, the first system we take into consideration is a point-to-point mm Wave MIMO system that employs a hybrid precoder and combiner with low-resolution PSs.

To send NOs data streams concurrently to the receiver, which is outfitted with  $N_r$  antennas and  $N_{OrRF}$  RF chains, the transmitter uses  $N_{Ot}$  antennas and  $N_{OtRF}$  RF chains. The number of data streams and the number of RF chains are limited to  $N_{Os}$ ,  $N_{Ot}$  to ensure spatial multiplexing and the effectiveness of mm Wave MIMO communication with a small number of RF chains.  $N_{RF} = N_{OrRF}$ . To keep things simple, let  $N_{ORF}$  stand for the total number of RF chains at both ends, i.e.,  $N_{ORF} = N_{Ot} = N_{Or}$ . The objective problem is divided into two distinct optimisations to facilitate the joint hybrid precoder and combiner design.

We first concentrate on the analogue precoder  $F_{RF}$  and combiner  $W_{RF}$ 's joint design. Then, given the derived ideal analogue precoder and combiner associated with the effective baseband channel, the digital precoder  $F_{BB}$  and combiner  $W_{BB}$  are computed to further maximise the spectral efficiency [3]. We take into account the realistic and hardware-efficient case in which PSs have low resolution to cut down on complexity and power usage. We intend to jointly design the hybrid precoder and combiner for a mmWave MIMO system under this hardware restriction. The possible spectral efficiency for Gaussian symbols conveyed over the mmWave MIMO channel is given by





**Jagadeesh Chandra Prasad et al.,**

$$S = \log_2 \left( \left( I_{NO_s} + \frac{P}{NO_s} R_n^{-1} B_{BB}^H B_{RF}^H H A_{RF} A_{BB} \right. \right. \\ \left. \left. \times A_{BB}^H A_{RF}^H H^H B_{RF} B_{BB} \right) \right)$$

To increase spectral efficiency, we want to jointly construct the low-resolution analogue beamformers FRF and WRF as well as the digital beamformers FBB and WBB:

$$\{A_{RF}^*, A_{BB}^*, B_{RF}^*, B_{BB}^*\} = \text{argmax } S$$

$$\text{s. t. } A_{RF}(i, j) \in \mathcal{A}, \forall i, j, \\ B_{RF}(i, j) \in \mathcal{B}, \forall i, j,$$

$$\|A_{RF} A_{BB}\|_A^2 = NO_s$$

The optimisation problem is undoubtedly an NP-hard, non-convex problem. The next step is to try to break down the original issue into a number of smaller issues in order to find a less ideal, but still workable, solution.

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**Algorithm:** One-bit low resolution

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Input:  $O_l$

Output:  $a_{RF,l}^*$  and  $b_{RF,l}^*$

1. Calculate  $c_{l,1}$  and  $k_{l,1}$  by an SVD of  $O_l$ .
  2. Define the angles  $\hat{\psi}_i, i = 1, 2, \dots, NO_t$ .
  3. Map  $\hat{\psi}_i$  to  $\bar{\psi}_i, i = 1, 2, \dots, NO_t$  in an ascending order.
  4. for  $m = 1 : NO_t$  do
  5. Obtain  $\hat{a}_{l,m}$
  6. Obtain  $\hat{a}_{l,m}$  from  $\bar{a}_{l,m}$  based on inverse mapping from  $\hat{\psi}_i$  to  $\bar{\psi}_i, i = 1, 2, \dots, NO_t$
  7. Obtain  $a_{l,m}$  from  $\hat{a}_{l,m}$
  8. end for
  9. Construct  $\mathcal{A}_l = \{a_{l,1}, \dots, a_{l,NO_t}\}$ .
  10. Construct  $\mathcal{B}_l$  by a similar procedure as steps 2-9.
  11. Find the optimal  $a_{RF,l}^*$  and  $b_{RF,l}^*$ .
- 

The 1-bit low resolution algorithm is a digital signal processing algorithm used in wireless communication systems to reduce the complexity and power consumption of the communication system. In this algorithm, the signal is quantized to a single bit, which greatly reduces the data size and complexity of the system. Despite the reduction in resolution, the 1-bit low resolution algorithm can still provide significant performance improvements in the communication system. The algorithm reduces the complexity of the system and can significantly reduce the power consumption of the system, making it suitable for low-power wireless devices. The steps of algorithm can be explained as the following:

First initialize the analog beamformer and combiner matrices, arf and brf. Calculate the effective channel matrix  $O = H * brf * arf$  using the current arf and brf matrices and then construct the one-bit codebook for the effective channel  $O$  using the function `one_bit_codebook_construction()`. This generates a set of quantized phase shifters that can be implemented in hardware. After that calculate the maximum expected signal power for each possible quantization level using the constructed codebook and effective channel matrix.

Select the quantization level with the maximum expected signal power for each RF chain and update the analog beamformer and combiner matrices accordingly.





Jagadeesh Chandra Prasad *et al.*,

Repeat steps 2-5 until convergence is achieved or the maximum number of iterations is reached. Calculate the digital beamformer  $ad\_qt1$  and combiner  $bd\_qt1$  using singular value decomposition (SVD) on the effective channel matrix  $Heff\_qt1 = brf \cdot Harf$ . Normalize the columns of  $ad\_qt1$  and  $bd\_qt1$  to satisfy the power constraint. Calculate the final digital beamformer  $a = arf \cdot ad\_qt1$  and digital combiner  $b = brf \cdot bd\_qt1$ .

Overall, this algorithm optimizes the analog beamformer and combiner matrices to maximize the signal-to-noise ratio (SNR) while using one-bit resolution phase shifters to reduce hardware complexity and cost. The hybrid precoding technique is used to separate the analog and digital precoding stages, resulting in improved performance compared to traditional analog-only precoding techniques. This algorithm optimizes the analog beamformer and combiner matrices to maximize the signal-to-noise ratio (SNR) while using one-bit resolution phase shifters to reduce hardware complexity and cost. The hybrid precoding technique is used to separate the analog and digital precoding stages, resulting in improved performance compared to traditional analog-only precoding techniques.

## SIMULATION RESULTS

In comparison to existing strategies, the suggested one-bit low-resolution algorithm and low-resolution phase shifter precoding methodology performed satisfactorily in the system. Plotting the spectrum efficiency of three cutting-edge low-resolution hybrid beamformer designs, including the coordinate descent method (CDM) algorithm and the hybrid beamforming (HBF) algorithm, is done for comparison purposes. The graph below shows how the suggested approach outperforms the alternatives, especially when using phase shifters (PSs) with 1-bit precision. Additionally, it can be seen that the proposed technique with  $B = 2$  performs nearly optimally for hybrid beamforming with infinite-resolution PSs and full-digital beamforming.

Iteration number refers to the number of times a signal is processed or transmitted through a system. In communication systems, iterative processing is often used to improve the quality of the received signal by correcting errors and reducing interference. Increasing the number of iterations in a communication system can improve spectral efficiency by reducing errors and interference. This is due to the fact that iterative processing can aid in error correction and enhance the received signal's signal-to-noise ratio (SNR). However, there is a trade-off between spectral efficiency and the number of iterations. As the number of iterations increases, the processing time and complexity of the system also increase. This can lead to higher power consumption, higher latency, and increased cost. The spectral efficiency can therefore be maximised while processing time and complexity are reduced by using an ideal number of iterations. This optimal number of iterations can vary depending on the specific system and the channel conditions. In the picture below, we contrast the proposed one-bit resolution algorithm with the full digital technique to assess the influence of the approximations utilised in its development. The spectral efficiency attained by the suggested method is almost identical to that of the full digital, as seen in the figure below.

As the SNR increases, the spectral efficiency (SE) also increases, but at a decreasing rate. At low SNRs, increasing the SNR can have a significant impact on the SE, but as the SNR becomes large, further increases in SNR have a diminishing effect on the SE. This relationship is often depicted in a plot of SE versus SNR, which is commonly referred to as SNR curve.

The sum-rate versus SNR for several hybrid beamformer types is shown in the picture below. We compare three cutting-edge multiuser hybrid beamforming techniques in particular: I-HB (iterative hybrid beamforming) and TS-HB (two stage hybrid beamforming). The two algorithms use techniques that rely on codebooks. The figure below shows that the performance of our suggested low-resolution design is superior than that of other algorithms using only 2-bit resolution PSs. Also comparable is the performance with 1-bit resolution PSs. Therefore, the results in comparison with other methods are very efficient and we can observe that we achieved a good spectral efficiency and sum rate in the above figures.





**CONCLUSION**

In this project, the issue of designing a hybrid precoder and combiner for mmWave MIMO systems with low-resolution quantized PSs was taken into consideration. For each data stream, the low-resolution analogue precoder and combiner pair are designed sequentially by an effective iterative process. In order to further improve the spectral efficiency, the digital precoder and combiner were then calculated using the discovered effective baseband channel. It was also looked at how low-resolution hybrid beamformers could be designed for multiuser MIMO communication systems. The efficiency of the suggested algorithms was confirmed by simulation results, particularly for situations involving one-bit resolution phase shifters.

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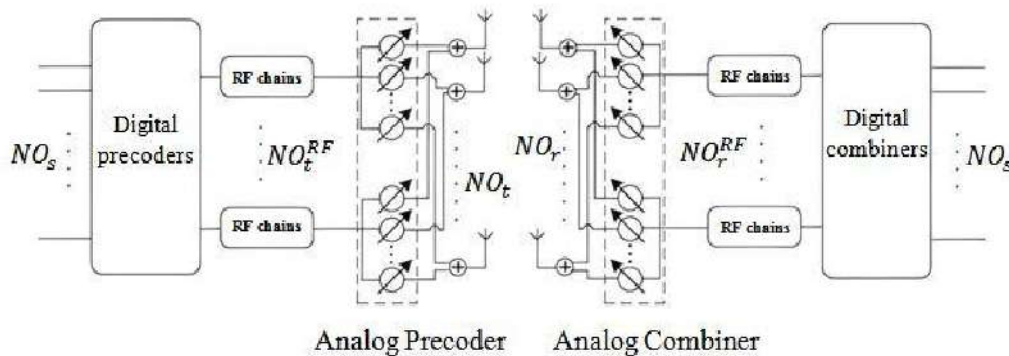


Fig. 1: Hybrid precoder and combiner point-to-point mmWave MIMO system





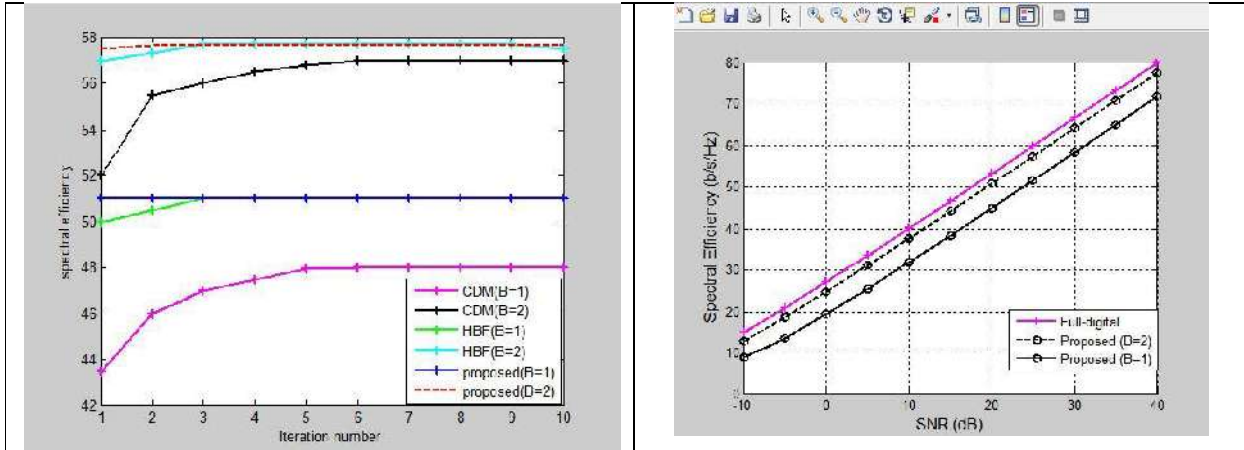


Fig. 2: Spectral Efficiency Vs Iteration number

Fig. 3: Spectral Efficiency Vs SNR

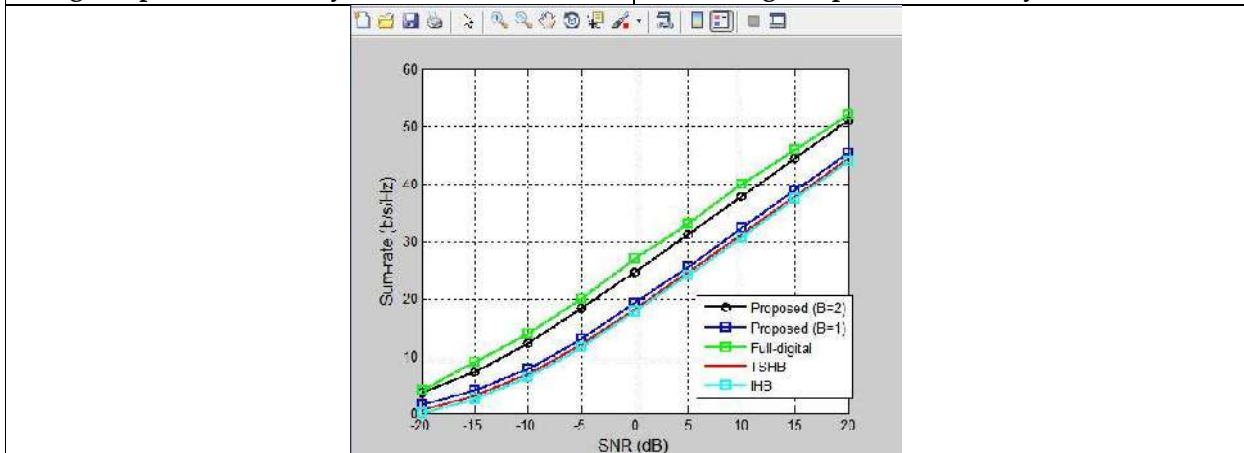


Fig. 4: Sum-rate Vs signal-to-noise ratio (SNR)





## Effect of Chemical Seed Priming on Crop Growth and Yield Traits of Okra [*Abelmoschus esculentus* (L.) Moench] CV. Arka Anamika

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### ABSTRACT

To study the effect of seed priming on crop growth parameters of okra, a field experiment was conducted. For this experiment, seeds were primed in various chemical substances, namely MnSO<sub>4</sub> 5%, MgSO<sub>4</sub> 5%, ZnSO<sub>4</sub> 5%, KCl 5%, CaCl<sub>2</sub> 5%, PEG 6000 5% while the untreated seeds were used as control. The growth and yield parameters such as days to 50 % flowering, number of branches per plant, plant height at maturity, fruit length, single fruit weight, number of seeds per fruit and 100 seed weight were observed. The highest growth and yield traits were recorded in PEG 6000 5% primed seeds, while untreated seeds proved to be the poorest. Hence, the study showed the promising effect of chemical seed priming in okra.

**Keywords:** Okra, PEG 6000, seed priming.





## INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench], is a member of the Malvaceae family and is renowned for its high nutritional value, which includes thiamine, vitamin B6, folic acid, riboflavin, vitamin B2, zinc, and dietary fibres. Okra is also known as "the perfect villager's vegetable" due to its high content of vitamins and minerals. Okra seeds are hard, and depending on the soil and temperature, emergence occurs over a long period of time after seeding (Demir and Ermis 2004). The status of a crop greatly depends on the seed materials used for sowing and how well they respond to other inputs used in crop production. Seed is a fundamental input in agriculture and is essential to its development. Pre-sowing seed treatment known as "seed priming" involves soaking seeds in an osmotic solution, which permits seeds to take up water and proceed through the early stages of germination but prevents radicle protrusion through the seed coat. The seeds can be kept or planted using traditional methods after being dried to their original moisture content. When the seedlings emerge, they will be stronger to handle any environmental obstacles (Afzal et al., 2016). During the soaking and dehydration processes, priming may cause a little abiotic stress. This enables the seeds to withstand environmental challenges as the seedlings grow. Keeping this, a field study was carried out to assess the role of seed priming with chemicals on crop growth and seed yield parameters of okra cv. Arka Anamika.

## MATERIALS AND METHODS

The experiment was carried out at paravanur village, Thanjavur district located at 11° 05' 36.6" N Latitude and 79° 25' 54.1" E Longitude with altitude of 21 meters above mean sea level during the year 2021–2022. Pure and cleaned seeds of okra cv. Arka Anamika were primed with the following chemicals as below.

### Preparation of Priming Solutions

A 5% solution was made using chemicals including  $MnSO_4$ ,  $MgSO_4$ ,  $ZnSO_4$ , KCl,  $CaCl_2$ , and PEG 6000. To make the solutions, 5 g of each chemical salt were dissolved in 100 ml of distilled water. The seeds were then soaked for 4 hours in an equivalent volume of the solution (1:1). The soaking seeds were dried until they had no more moisture than before. In field tests, the above-mentioned seeds were assessed for features related to crop growth and yield.

### Treatment Details

T<sub>0</sub> – Unprimed (Control)

T<sub>1</sub> – 5%  $MnSO_4$

T<sub>2</sub> – 5%  $MgSO_4$

T<sub>3</sub> – 5%  $ZnSO_4$

T<sub>4</sub> – 5% KCl

T<sub>5</sub> – 5%  $CaCl_2$

T<sub>6</sub> – 5% PEG 6000

The primed seeds and unprimed seeds were evaluated through field trial by adopting a randomized block design (RBD) with three replication spaced as 60 x 45 cm, followed the recommended set of practices for okra. Ten plants were randomly selected replicationwise marked in each of the treatments and the following observation was recorded i.e., days to 50% flowering, number of branches per plant, plant height at maturity (cm), fruit length (cm), Single fruit weight (g), number of seeds per fruit and 100 seed weight (g). For statistical analysis, the technique described by Panse and Sukhatme (1985) was adopted.

## RESULTS AND DISCUSSION

The seeds primed with priming solutions were evaluated under field condition along with untreated (control) seeds for vegetative and reproductive growth of okra. The biometrical parameters were observed for each treatment





Mohamed shafiq *et al.*,

replication wise. It revealed that the 5% PEG 6000 (T<sub>6</sub>) primed seeds recorded higher values for biometrical traits *viz.*, days to 50% flowering (37), number of branches per plant (11.0), plant height at maturity (77.07cm) and the minimum values were recorded in control seeds (Fig 1,2,3). Similar results have been earlier reported by Syaiful *et al.*, 2015. After planting, seeds spend a set amount of time in the soil soaking up water and vital nutrients for growth. In addition to ensuring uniform germination, seed priming shortens the time needed for germination. Numerous proteins, lipids, and enzymes that are involved in the mobilisation of reserve energy are also expected to become more active after priming. In order for the embryo to absorb, develop, and grow, these enzymes convert macromolecules into micro molecules (Jisha and Puthur, 2016). Seed priming with PEG 6000 can increase seed germination, seedling quality, and drought tolerance (Rahimi, 2013).

PEG 60005% (T<sub>6</sub>) primed seeds also recorded higher values in fruit length (19.53 cm), fruit weight (39.67g), number of seeds per fruit (52.67) and 100 seed weight (4.96g) (Fig 4,5,6,7). These findings are in line with (Sharma *et al.*, 2018, Debbarma *et al.*, 2018, Kumar *et al.*, 2017 and Shim *et al.*, 2009). Improved biometrical traits might be due to significantly improved chlorophyll content and root viability in PEG primed seeds, they maintained high relative water content under adverse soil moisture environments leading to better field performance. This priming treatment decreased soluble sugars, increased proline concentration, boosted free amino acid activity, and decreased electrolyte leakage, therefore resulting in increased stress tolerance (Zhang *et al.*, 2012). PEG primed seeds show increase in oxygen metabolism activity (Jie *et al.*, 2002) leading to increased vigour (Yari *et al.*, 2010). The primed seed emerges quicker and more uniformly, and seedlings grow more aggressively, resulting in a variety of phenological and yield-related benefits, which may explain why primed seed plots produce more grain (Harris *et al.*, 2000). Treatment with PEG 6000 also improved seed stress tolerance by improving germination performance at sub optimal temperatures (5°-20°C) and under water stress conditions (Chen *et al.*, 2010). Therefore, seed primed with 5% PEG 6000 may be suggested for better okra productivity and quality seed production.

## CONCLUSION

Based on the results obtained from the investigations it can be concluded that the 5% PEG6000 primed seeds of okra cv. Arka Anamika recorded the higher crop growth and yield traits such as days to 50 % flowering (37), number of branches per plant (11.0), plant height at maturity (77.07cm), fruit length (19.53cm), Single fruit weight (39.67g), number of seeds per fruit (52.67) and 100 seed weight (4.96g) when compared to other treatments and control. Hence, it can be suggested that performance of growth and yield parameters of okra can be improved by seed priming treatment with 5% PEG 6000.

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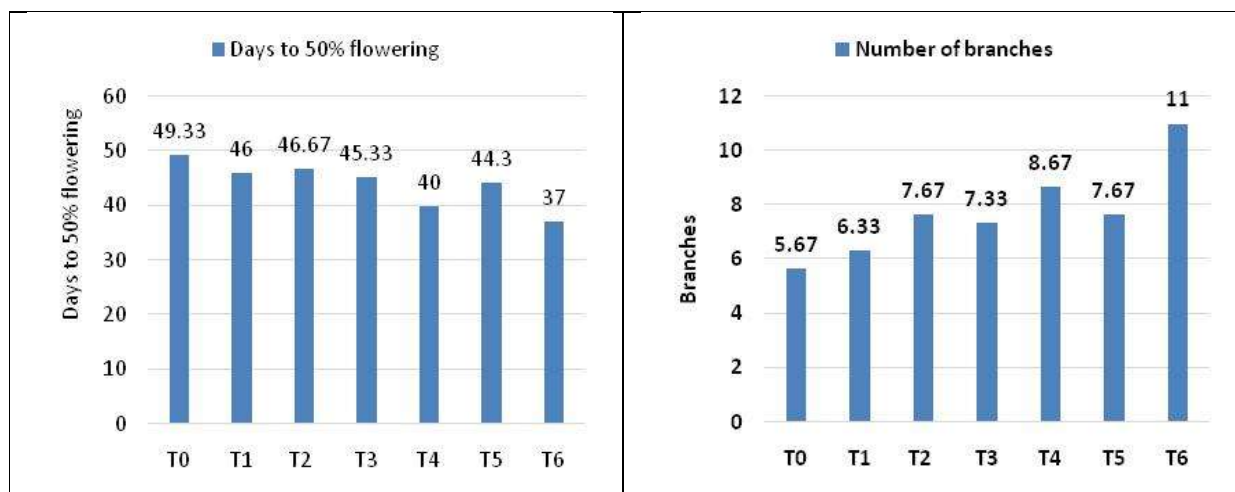
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**Figure 1. Effect of different chemical priming on Days to 50% flowering**

**Figure 2. Effect of different chemical priming on Number of branches**







Mohamed shafiq et al.,

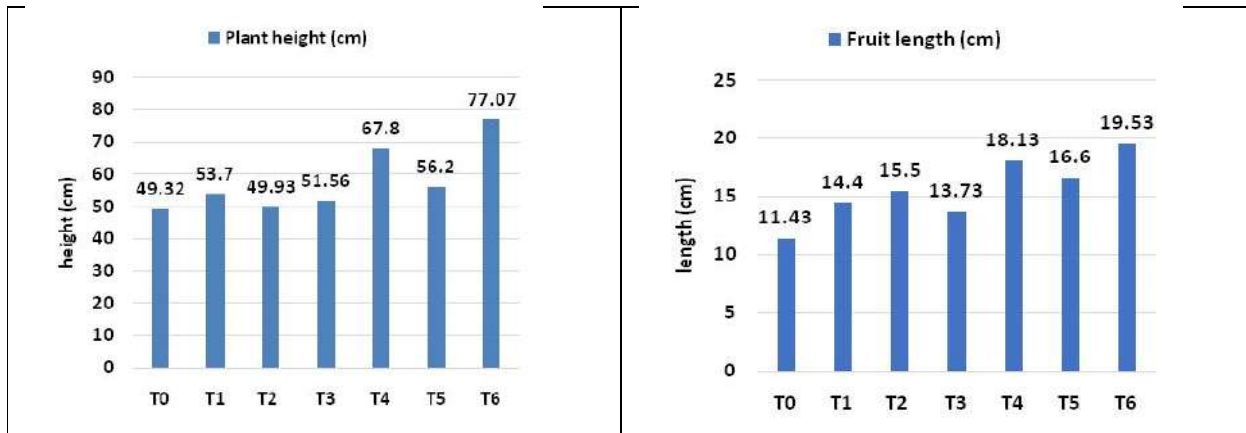


Figure 3. Effect of different chemical priming on plant height (cm)

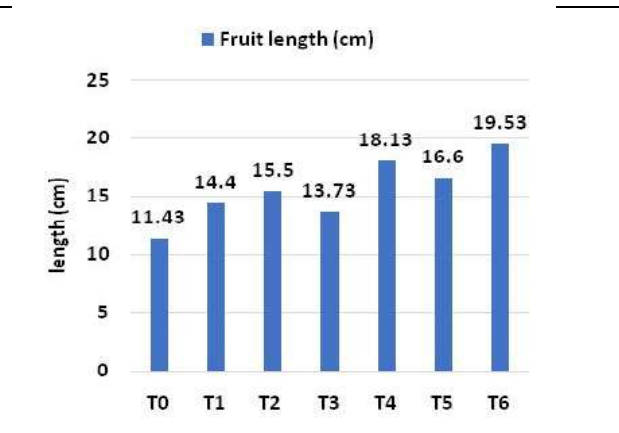


Figure 4. Effect of different chemical priming on fruit length (cm)

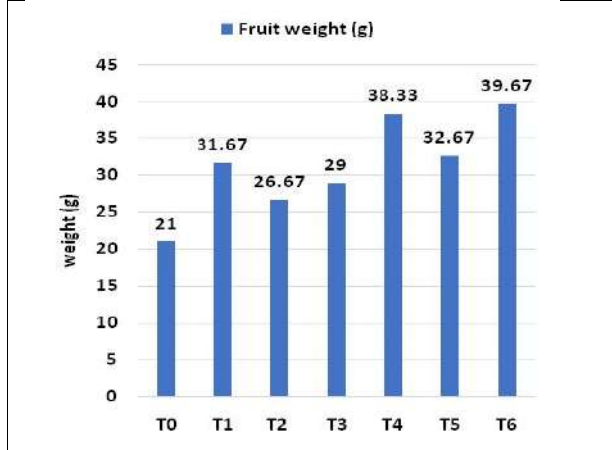


Figure 5. Effect of different chemical priming on fruit weight (g)

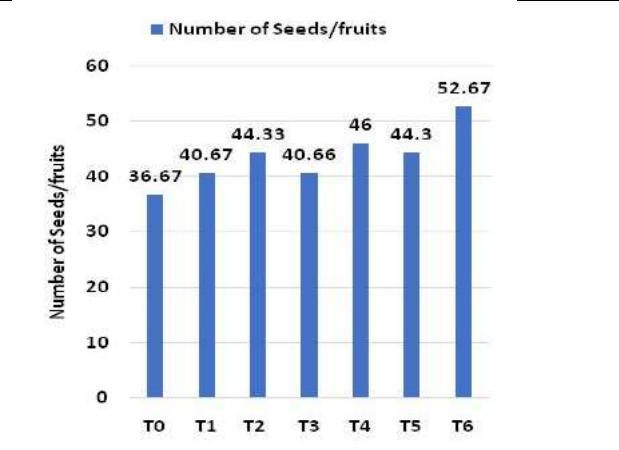


Figure 6. Effect of different chemical priming on Number of Seeds/fruits

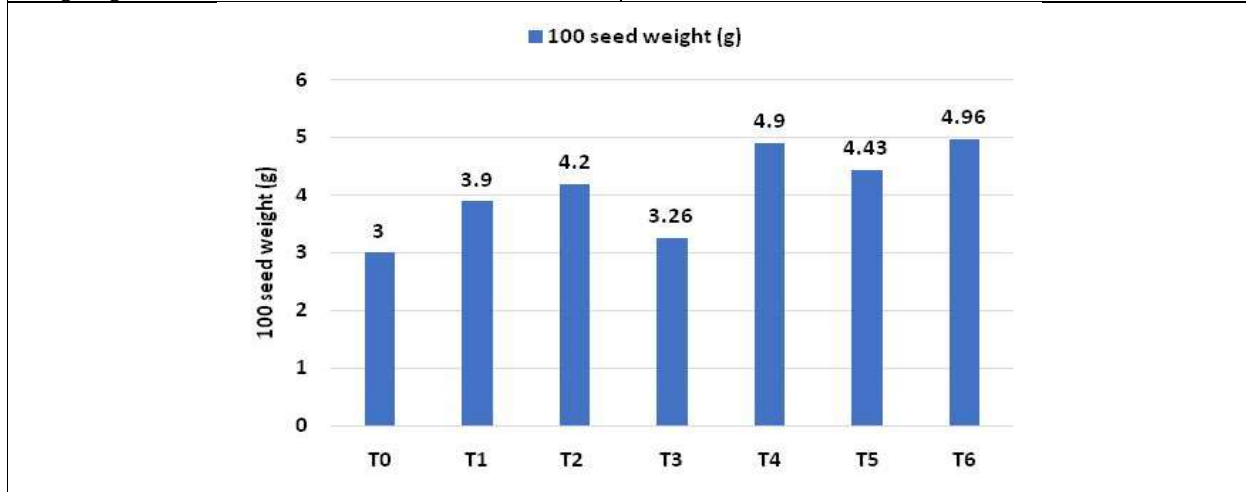


Figure 7. Effect of different chemical priming on 100 seed weight (g)





## A Study to Evaluate the Morphometric Measures of Gonial Angle and Bi-gonial Width for Healthy Individuals in Garden City University Dental Camp.

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### ABSTRACT

The present study conducted in Garden City University aimed to investigate the correlation between two mandibular parameters, namely the gonial angle and bi-gonial width, with age and gender in dentate subjects visiting a dental camp. The study has been carried out on a Dental camp organized by Garden City University, Bangalore. The study population consists of 152 healthy subjects, out of 74 males and 78 females aged between 18-30 years. All the subjects having normal facial features and not having any history of joint surgery, facial trauma, temporomandibular disorders or any syndromes affecting face or jaw were included in this study. A mathematical protractor is used to measure the gonial angle (measured by an illustrative tangent line that runs along the inferior border of the mandible and the posterior border of the ramus. The intersection of these two lines formed the gonial angle, which was measured either on right or left side) and inch tape is used to measure the bi-gonial width (distance between the two Gonion is the bi-gonial width. The gonion is the exterior angle of the mandible's most inferior, posterior, and lateral point). The present data shows the range of measurements of gonial angle for male participants was between 110 and 155 mm. The average of gonial angle measurement (mean) for males was 137.55 mm, with a standard deviation of 11.268 mm. For female participants, the range of measurements of gonial angle was between 110 and 142 mm. The average gonial angle measurement (mean) for females was 127.02 mm, with a standard deviation of 9.503 mm. Similarly, the bi-gonial width, which represents the distance between the two angles of the mandible, exhibits a mean value of 6.95 inches in males and 6.05 inches in females. The range of bi-gonial width measurements for males was

70550





Sandhya Nagolu *et al.*,

between 5.6-8.6 inches and females was between 4.5-7.9 inches. These findings suggest that there are average differences in the gonial angle and bi-gonial width between males and females. One of the most significant and frequently utilised radiographic markers in orthodontic tracing is the gonial angle and bi-gonial breadth, which is used to assess the growth pattern and plan the course of treatment. The current study's findings reveals that 1- Gonial angle degree grew bigger in males and on the left side as people aged. 2- Males' bi- gonial width was wider and grew wider with age. Consequently, when people aged, their mandibles grew larger as a whole.

**Keywords:** Bi- gonial width, Gonial angle, Mandible, Morphometry, Sexual dimorphism.

## INTRODUCTION

The mandible, commonly known as the jawbone, is indeed the largest and strongest bone of the skull. It plays a crucial role in various functions such as chewing, speaking, and providing structural support to the face. Fehrenbach and Herring (2012). Certain anatomical landmarks of the mandible, such as the gonial angle, antegonial angle, mental foramen, mandibular foramen, and mandibular canal can undergo changes during life based on factors such as age, gender, and dental status. Regarding the patterns and rates of developing growth, it has been observed that the mandibular condyle and ramus exhibit a high degree of sexual dimorphism. Kambylatkas *et al.* (2006). The gonial angle is an important radio-morphometric index that refers to the angle formed by the intersection of two lines: one drawn along the lower border of the mandible (lower jawbone) and another drawn along the posterior border of the ramus of the mandible (the vertical portion of the jawbone). It is also known as the mandibular angle or the angle of the mandible. Ghosh *et al.* (2009). A person's mandible plays a significant part in determining the individual's facial features. The teeth and age condition throughout life have an impact on the morphological changes in the mandible. Evaluation of the effects of age and sex on the mandibular gonial angle is particularly relevant given the significance of maintaining facial aesthetics. Huuomonen *et al.* (2010). The average gonial angle in adults is around 120 to 135 degrees, but it can range from 90 to 170 degrees. In general, a more obtuse (larger) gonial angle is associated with a more square-shaped lower face, while a more acute (smaller) angle is associated with a more pointed or V-shaped lower face. It's important to note that the gonial angle alone cannot determine the overall shape and proportions of the face. It is just one of many factors that contribute to the overall facial aesthetics and harmony. Additionally, the gonial angle can change throughout a person's life due to growth, aging, and the effects of dental and orthodontic treatment. Chole *et al.* (2013). Clinically, the measurement of the gonial angle can be useful in orthodontics, oral and maxillofacial surgery, and forensic anthropology. In orthodontics, it helps in diagnosing and planning the treatment of malocclusions (improper alignment of the teeth and jaws). In oral and maxillofacial surgery, it assists in assessing facial asymmetry and planning corrective procedures. Forensic anthropologists also use the gonial angle as one of the parameters for identifying human remains. Saini (2013).

In the field of medicolegal practice, the identification of human remains is indeed crucial, and various methods are employed to achieve this. One such method involves evaluating the mandible (lower jawbone) and its characteristics. Indira *et al.* (2012). Apart from determining age and gender, measurements and landmarks on the mandible can be used for identification purposes. The gonial angle, specifically, has been found to be a useful tool in estimating age, especially in urgent situations like mass tragedies, excavated remains, violent dismemberment cases, or missing persons investigations. Williams *et al.* (2000) Accurate measurement and assessment of gonial angle values are essential in order to derive age and gender information from human remains. In this context, a mathematical protractor has been utilized to assess the anatomic gonial angle values. This approach aims to replicate the outcomes obtained through lateral radiography, which is a common method for measuring the gonial angle. By comparing the measured angle values with established age and gender standards, forensic experts can make determinations about the individual's identity and other pertinent information. Larheim and Svanaes (1986). The study conducted in Garden City University aimed to investigate the correlation between two mandibular parameters, namely the gonial





Sandhya Nagolu *et al.*,

angle and bi-gonial width, with age and gender in dentate subjects visiting a dental camp. The researchers were interested in exploring potential applications of this data in forensic cadaver identification and monitoring growth patterns of individuals in orthodontic assessments. The findings of this study could contribute to the field of forensic science by providing additional tools for cadaver identification. Furthermore, orthodontists and dental professionals may benefit from the knowledge gained regarding growth patterns in the mandible, facilitating more accurate treatment planning and assessments.

#### Aims and Objectives

- To assess the relation in measurements of gonial angle and age or gender among healthy adult individuals.
- To assess the association between bi-gonial width and age or gender.
- To assess the usefulness of the gonial angle and bi-gonial width of the mandible as forensic tools for age and gender prediction.

## MATERIALS AND METHODS

The study has been carried out on a Dental camp organized by Garden City University, Bangalore. The study population consists of 152 healthy subjects, out of 74 males and 78 females aged between 18-30 years. All the subjects having normal facial features and not having any history of joint surgery, facial trauma, temporo-mandibular disorders or any syndromes affecting face or jaw were included in this study. All study participants signed a general consent form, indicating their consent to the possibility of their data being used in clinical research initiatives.

**Procedure** A mathematical protractor is used to measure the gonial angle and inch tape is used to measure the bi-gonial width...

**Gonial angle** The gonial angle (also known as the mandibular angle) is measured by an illustrative tangent line that runs along the inferior border of the mandible and the posterior border of the ramus. The intersection of these two lines formed the gonial angle, which was measured either on right or left side. Lux *et al.* (2003).

**Bi-gonial width** The distance between the two Gonias is the bi-gonial width (Go). The gonion is the exterior angle of the mandible's most inferior, posterior, and lateral point. Al-Shamout *et al.* (2012)

## RESULTS

The present data shows the range of measurements of gonial angle for male participants was between 110 and 155 mm. The average of gonial angle measurement (mean) for males was 137.55 mm, with a standard deviation of 11.268 mm. For female participants, the range of measurements of gonial angle was between 110 and 142 mm. The average gonial angle measurement (mean) for females was 127.02 mm, with a standard deviation of 9.503 mm. (Table 1 & Graph 1) Similarly, the bi-gonial width, which represents the distance between the two angles of the mandible, exhibits a mean value of 6.95 inches in males and 6.05 inches in females. The range of bi-gonial width measurements for males was between 5.6-8.6 inches and females was between 4.5-7.9 inches (Table 2& Graph 2) These findings suggest that there are average differences in the gonial angle and bi-gonial width between males and females. These measurements could serve as important indicators when attempting to identify unidentified skeletons.

## DISCUSSION

By examining the pelvis, skull, and mandible, forensic anthropologists and osteologists can gather valuable clues about the biological sex of an individual, which can be crucial in forensic investigations or archaeological studies. However, it's important to note that sex determination based solely on skeletal remains is not always completely accurate, and additional methods and criteria, such as DNA analysis or a combination of different skeletal traits, may be employed to enhance the accuracy of sex estimation. Kumar and Lokanadham (2013).





**Sandhya Nagolu et al.,**

Sample Sizes of this study states that the male population consists of 74 subjects, while the female population has 78 subjects aged between 18-30 years. Studies on the morphology and morphometry of different populations and genders have revealed that the size and form of the gonial angle vary. Based on the current findings, mean values of gonial angle higher in males (137°) compared to females (127°) whereas the mean bi-gonial width for males is 6.95 inches, while for females, it is 6.09 inches. This indicates that there might be sexual dimorphism in the angle measurement, with males tending to have larger angles compared to females. These measurements suggest that there might be differences in mandibular size and shape between males and females. By utilizing these measurements and their respective mean values, researchers and forensic experts can potentially use the gonial angle and bi-gonial width as useful criteria in identifying unknown skeletal remains, particularly in differentiating between male and female individuals. The current findings in the study indicate that the gonial angle tends to increase in size as individuals age, with older age groups exhibiting larger and more flared angles compared to younger age groups. These results are consistent with previous studies that also observed similar age-related changes in the gonial angle. (Ghosh *et al.* (2009), Al-Shamout *et al.* (2012), Leversha *et al.* (2016)). However, there is a disagreement with the findings of Upadhyay *et al.*, as their study reported a decrease in the gonial angle with advancing age. Upadhyay *et al.* (2012). The contrasting results could be attributed to several factors such as differences in sample size, age range, racial composition of the samples, variations in measurement methods, and the type of radiographs used. In terms of gender differences, many authors have reported that females tend to have larger (wider) gonial angles than males across all age groups. (Ghosh *et al.* (2009), Chole *et al.* (2013),

Leversha *et al.* (2016), Joo *et al.* (2013), Taleb and Beshlawy (2015)). These findings contradict the results of the present study. On the other hand, some studies have found no correlation between the gonial angle and gender or have even suggested that males may have wider gonial angles. (Al-Shamout *et al.* (2012), Upadhyay *et al.* (2012), Dutra *et al.* (2004)). These discrepancies could be attributed to variations in sample size, sample ratios (male-to-female ratio), and racial diversity among the study populations. Additionally, when comparing the gonial angles of the right and left sides, the results of the present study indicate a greater angle in the left side for both genders and across all age groups. This finding aligns with the study conducted by Leversha *et al.* (2016). However, other studies have reported that the right side exhibits a greater gonial angle. (Kumar and Lokanadham (2013), Upadhyay *et al.* (2012)). These differences in findings may be attributed to variations in sample size, racial composition, and the specific method employed to measure the gonial angle. The findings revealed that bi-gonial width increased with age, which is consistent with the studies conducted by Al-Shamout *et al.* and Huuomeneen *et al.* (Al-Shamout *et al.* (2012), huuomeneen *et al.* (2010)). However, these results disagreed with the findings of Laversha *et al.*, who observed a steady decrease in bi-gonial width with increasing age. Leversha *et al.* (2016). The disparity in findings could be attributed to differences in sample size, age range, group distribution, and ethnicity among the study populations. Furthermore, the present study found that, on average, males had a higher bi-gonial width than females, which aligns with the findings of both Al-Shamout *et al.* and Laversha *et al.* (Al-Shamout *et al.* (2012), Leversha *et al.* (2016)). It's important to note that the accuracy and applicability of these indicators may vary based on the specific population studied, the sample size, and other factors. Additionally, further research and validation studies are typically required to establish the reliability and validity of these measurements for forensic identification purpose.

## CONCLUSION

One of the most significant and frequently utilised radiographic markers in orthodontic tracing is the gonial angle and bi-gonial breadth, which is used to assess the growth pattern and plan the course of treatment. Evaluations of these sites are crucial for forensic dentistry as a foundational reference as well as for comparison with other countries and races.

1-Gonial angle degree grew bigger in males and on the left side as people aged.

2- Males' bi-gonial width was wider and grew wider with age. Consequently, when people aged, their mandibles grew larger as a whole.







Sandhya Nagolu et al.,

**Conflict of Interest** None**Acknowledgements** None**REFERENCES**

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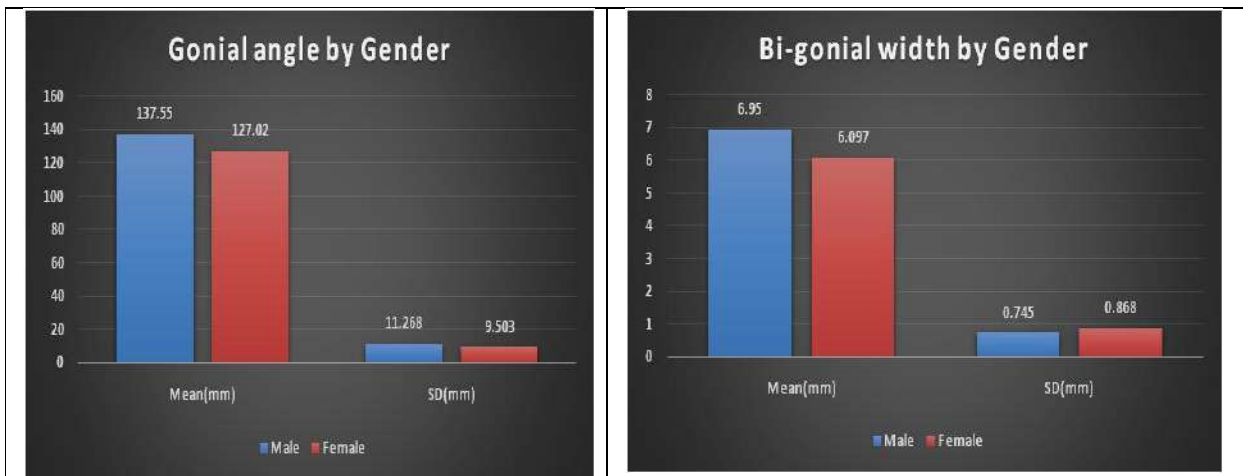
**Sandhya Nagolu et al.,**

**Table 1 Showing Gonial angle in age group 18-30 years**

Sex	No of Subjects	Range (degree)	Mean(degree)	SD(degree)
Male	74	110-155	137.55	11.268
Female	78	110-142	127.02	9.503

**Table 2 Showing Bi-gonial width of lower jaw in age group 18-30 years**

Sex	No of Subjects	Range (inch)	Mean(inch)	SD(inch)
Male	74	5.6-8.6	6.95	0.745
Female	78	4.5-7.9	6.097	0.868



**Graph 1: Gonial angle by Gender in age group 18-30 years**

**Graph 2: Bi- Gonial width by Gender in age group 18-30 years**





## Evaluation of Effectiveness of Remedial Measures on Pesticide Residues in Grapes

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### ABSTRACT

The extensive use of pesticides in agriculture has become a very common practice in developing countries like India. They have been used in agriculture to increase the yield, quality and extend the storage life of crops. The continuous uses of these pesticides have resulted in contamination of the environment, crops and also caused potential risk to human health includes adverse health effects, called acute effects (stinging eyes, rashes, blisters, blindness, nausea, dizziness, diarrhea and death), as well as chronic adverse effects that can occur months or years after exposure (cancers, birth defects, reproductive harm, immunotoxicity, neurological and developmental toxicity, and disruption of the endocrine system). It has been stated that washing food samples in water or soaking in salt solutions, lime water is effective in reducing the pesticide level. From the survey results, it was found that the commonly used home remedies for washing food samples are normal water, vinegar, turmeric water, salt solution by rinsing and soaking for more than 10 mins. This work is done to determine the effect of these common home remedies in reducing the pesticide residue level in grapes. For this purpose, the grapes are bought from local market, divided, washed by different methods and dried. Then each session is extracted and pesticides are detected by QuEChERS and GC-MS method respectively. The results shows that chlorpyrifos, fenvalerate and ethion are the pesticides present in sample in which chlorpyrifos exceeds





Manu Jose *et al.*,

the MRL. And none of the above home remedies found effective in reducing the pesticide residue level in grapes to a greater extent.

**Keywords:** Home remedies, QuEChERS, GC-MS, Chlorpyrifos, Ethion, Fenvalerate

## INTRODUCTION

Pest control agents are compounds known as pesticides. Pesticides come in a wide variety of forms, each of which is intended to be efficient against a particular pest [1]. Pesticides can be either biological (bio-pesticide) or inorganic synthetic (made synthetically) in nature [2]. The most widely used pesticides with the highest levels of bioaccumulation and toxicity are called organochlorine (OC) pesticides [3]. The majority of pesticides are designed to act as crop protection agents, or plant protection products, which often shield plants from weeds, fungi, or insects. When a pesticide is applied, spilled, or dumped, it leaves behind deposits of the pesticide's active ingredient, as well as any metabolites or breakdown products. The kind and extent of any chemical pollution in the environment, as well as its persistence, are measured by residue analysis. In order for governments to register pesticides for use legally in certain applications, they must undergo comprehensive effectiveness, environmental, and toxicological testing. The types and amounts of residues that are legally allowed to be present on foods are limited by regulatory organisations across the globe by the maximum residue levels (MRLs), sometimes known as "tolerances" in the United States [3]. One of the key factors for raising crop yield in agriculture is the use of pesticides. Consumers have little control over the pesticide residues that are left in food after harvesting and that have a negative impact on human health. The location of pesticides in food varies depending on the pesticide's molecular make-up, the kind and quantity of food, and environmental conditions. Because the amounts of these chemicals present in food crops treated with pesticides are always unknown, it is essential to identify some other methods for cleaning up food. It has been stated that washing in water or soaking in salt solutions with various chemicals, such as chlorine, chlorine dioxide, hydrogen peroxide, ozone, acetic acid, hydroxy peracetic acid, iprodione, and detergents, is very efficient in lowering the level. The mainly used organic methods include using lime water, turmeric solution are also effective in reducing the level [4]. Pesticide residues in fruits and vegetables can be detected using a variety of pre-treatment and extraction methods, such as liquid-liquid extraction (LLE), solid phase extraction (SPE), solid phase microextraction (SPME), matrix solid phase dispersion (MSPD), quick, easy, cheap, effective, rugged, and safe method (QuEChERS), gel permeation chromatography (GPC), liquid-liquid microextraction (LLME), capillary electrophoresis (CE), etc [5].

## MATERIALS AND METHODS

Survey among housewives on awareness about pesticide usage in vegetables or fruits and its home remedies [6]. This survey aims to come out with the most commonly used home remedies in households for washing food samples. The survey was conducted at Nirmala College of Pharmacy, Muvattupuzha consisting of population 550 including students and their parent who is more aware of the pesticide usage and washing methods.

Cochran formula  $n_0 = z^2pq/e^2$  where  $n_0$ = sample size,  $z$ = value found in the  $z$  table at a given confidence level,  $p$ = estimated proportion of an attribute that is present in the population,  $q= 1-p$ ,  $e^2$ = desired level of precision.

According to the Cochran formula, for 550 students the sample size should be more than 227. (Confidence level= 95%, Margin of error= 5%, Population proportion= 50%) Total we took 263 responses.

Survey Questions [7]. Initially we took the details of the participant such as age, education qualification and willingness to take part in survey. Following were the questions added in survey.

### Determination of Pesticide Residue [8]

Sample Collection: Total 3 kg of grape sample were collected from different local markets of Ernakulam District.



**Manu Jose et al.,**

Sample washing: Collected samples were washed by using four different methods. They are washing samples by using normal water, 10% turmeric water, 10% salt solution, 10% acetic acid in water (vinegar). Samples are soaked in these four different liquids for 15 minutes and then dried. Extraction of samples: firstly sample is homogenised. About 10g of sample was transferred to a 50ml polypropylene tube. To it add 10ml of acetonitrile, 8g magnesium sulphate, 1g sodium chloride/sodium acetate. Mix vigorously for 1 minute and centrifuge for 5min at 5000ppm. Transfer the acetonitrile layer into 20ml centrifuge tube. Dispersive solid phase extraction were performed. For clean up QuEChERS performed. Vortex QuEChERS powder. Centrifuge at 6000rpm for 5minutes, then collect 5ml of supernatant in dry beaker. Reconstitute with 0.5ml of petroleum ether.

Detection and Estimation by GC-MS : Mobile phase: He gas, Column: DB 5MS 30 m x 0.250mm Diameter x 0.25 µm Thickness, Flow Rate: 1.2ml/min Detector: Triple-Axis HED-EM detector Ionization Source: Electron Impact Ionizer Quantification: For each compound, create a five-point calibration (including zero) spanning from 0.1 ng/µl to 2 ng/µl (1 ng/µl = 1ppm). The calibration graph is used to calculate the amount of each chemical in the sample.

**Calculations:**

Concentration of pesticides (ppm) =  $\frac{\text{Standard concentration}}{\text{Sample concentration}} \times 10000 \times 100$

Sample concentration(ppm) =  $\frac{\text{Weight of the sample taken (g)}}{\text{Made up volume (ml)}} \times \text{Dilution factor} \times 1000 \times 1000$

**RESULTS AND DISCUSSION****Survey results**

From the survey results, we can observe that most of the participants are aware of the pesticide usage from media and friends. They are of the opinion that pesticides can be used only to a permissible limit. It was also reported that most of the participants use both rinsing and soaking methods for washing the food samples. And the main home remedies they use are normal water, turmeric water, salt solution and vinegar in which they soak for more than 10 minutes.

**Calibration results**

Calibration graphs of the pure standards of pesticides are plotted by taking area in Y axis and concentration in X axis extending from 0.1 to 3 ppm. The five point calibration graph of chlorpyrifos, ethion and fenvalerate gives a straight line with the average R2 of 0.99. The concentration of the pesticide in injected sample is determined by extrapolating the observed area to the X axis.

The above table gives the data on retention time, peak height, peak area of each pesticide of the control sample. The report indicates that the chlorpyrifos is present in highest amount than the other two pesticides. The level of chlorpyrifos also exceeds the MRL. The first curve of the chromatogram is the peak of chlorpyrifos, second curve is the peak of ethion and third curve is the peak of fenvalerate. The peak area is converted to the concentration of pesticides with the help of calibration graph. This concentration of each pesticide in control sample is taken as the standard value for the comparison of pesticide level after different washing methods.

The above table gives the data on retention time, peak height, peak area of each pesticide of the grape sample washed by normal water. The first curve of the chromatogram is the peak of chlorpyrifos, second curve is the peak of ethion and third curve is the peak of fenvalerate. The peak area is converted to the concentration of pesticides with the help of calibration graph. Compared to the control sample there is no much reduction in the level of pesticide residue in grape sample washed by normal water.







**Manu Jose et al.,**

The above table gives the data on retention time, peak height, peak area of each pesticide of the grape sample washed by salt water. The first curve of the chromatogram is the peak of chlorpyrifos, second curve is the peak of ethion and third curve is the peak of fenvalerate. The peak area is converted to the concentration of pesticides with the help of calibration graph. Compared to the control sample there is no much reduction in the level of pesticide residue in grape sample washed by salt water

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.4-0.9 which shows that there is no much deviation in the values obtained

The above table gives the data on retention time, peak height, peak area of each pesticide of the grape sample washed by vinegar. The first curve of the chromatogram is the peak of chlorpyrifos, second curve is the peak of ethion and third curve is the peak of fenvalerate. The peak area is converted to the concentration of pesticides with the help of calibration graph. Compared to the control sample there is no much reduction in the level of pesticide residue in grape sample washed by vinegar

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.4-0.8 which shows that there is no much deviation in the values obtained

The above table gives the data on retention time, peak height, peak area of each pesticide of the grape sample washed by turmeric water. The first curve of the chromatogram is the peak of chlorpyrifos, second curve is the peak of ethion and third curve is the peak of fenvalerate. The peak area is converted to the concentration of pesticides with the help of calibration graph. Compared to the control sample there is no much reduction in the level of pesticide residue in grape sample washed by turmeric water.

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.3-0.5 which shows that there is no much deviation in the values obtained.

From the survey results, we can observe that most of the participants wash fruits and vegetables two times by rinsing and soaking for more than 10mins. The most commonly used home remedies are normal water, salt solution, turmeric water and vinegar. From the results of the analysis of the control sample, it was found that three main pesticides are present in grape sample i.e., chlorpyrifos, fenvalerate and ethion. Among these three pesticides, chlorpyrifos has been used highest than other two. Chlorpyrifos is used above their MRL value and rest two of the pesticides are within the range.

Results obtained after washing with 4 home remedies i.e., normal water, turmeric water, salt solution and vinegar indicate that none of the solution could reduce the pesticide residue level in sample to a greater extend.

From the graph it is observed that normal water was able to slightly reduce the pesticide level in grapes. But this can vary according to the pesticide as some are more soluble in water and some are not.

## SUMMARY AND CONCLUSION

From the results it was seen that chlorpyrifos was used highest. Continuous intake of small proportion of chlorpyrifos will result in headaches, blurred vision, and salivation and to a greater exposure it can cause seizures, coma and death. Whereas exposure to a higher dose of fenvalerate was found to be toxic to testes and epididymis which can cause reduced sperm count and infertility. And ethion is also not less harmful than these two. Continuous intake of pesticide applied food sample can result in accumulation of toxins inside the body which can cause health hazards. . Hence it is very important to consider the amount of pesticide taken through our daily diet. From this research article it was found that none of the common home remedies was found to be effective in reducing the pesticide residue level. These washing methods are used in all the households with the belief that after using these



**Manu Jose et al.,**

home remedies, the pesticides are completely removed from the food sample which is not actually true. Use of herbal wash or veggie wash could reduce the pesticide level to a greater extent as they contain a large proportion of organic products with effective chemicals. Organic farming is the best method to reduce the pesticide exposure as they mainly use organic products such as neem oil, made from the neem tree, and pyrethrin, which is made from chrysanthemum plants as pest control agents. Hence it is very important to reach this knowledge to the common people, farmers and make them aware of the severe health hazards awaiting for them if controlling measures are not taken properly.

**CONFLICT OF INTEREST**

There is no conflict of interest regarding this investigation

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**Manu Jose et al.,**

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**Table 1. Survey questions**

Sl No.	Question	Options					
1	Where do you get your fruits/vegetables from?	Hypermarket	Local market	Self cultivation	All of the above		
2	How often do you buy fruits/vegetables?	Twice a week	Once a week	Once in a 2 week	Once in a month		
3	Are you aware about the pesticides being used in fruits/vegetables?	Yes	No	Maybe			
4	If yes, what was the source of information?	Media	Friends	Awareness programs	Healthcare professionals		
5	What is your opinion regarding pesticide usage?	Don't use pesticides at all	Use pesticides only to a permissible limit	Use pesticides above the limit			
6	Are you aware about pesticide control measures?	Yes	No	May be			
7	Which one of the following do you opt for washing fruits and vegetables?	Normal water	Vinegar solution	Salt water	Lime water	Turmeric water	Others
8	Number of washing sessions	One	two	Three	More		
9	How do you wash your fruits or vegetables?	By rinsing	By soaking	Both rinsing and soaking			
10	If soaking, how long do you soak your fruits/vegetables for?	No soaking	0-5 minutes	5-10 minutes	More than 10 minutes		
11	Does any member of your family experience any kind of discomfort after consuming fruits or vegetables? If so, please mention the details.						

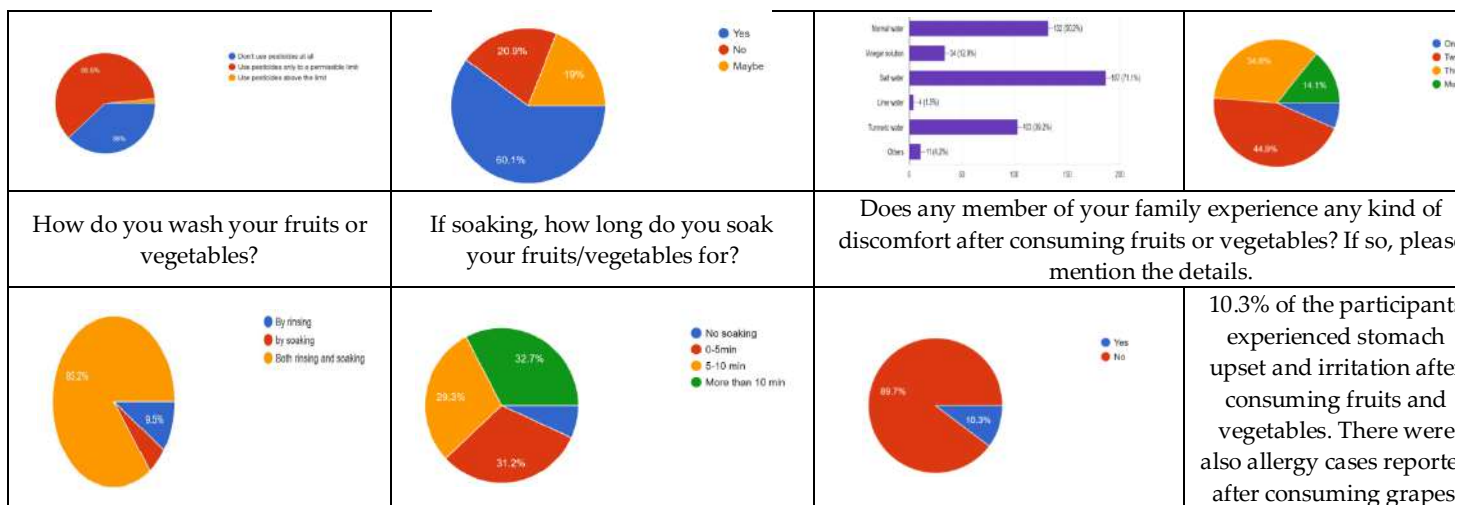
**Table 2. Survey results**

Where do you get fruits and vegetables from?	How often do you buy fruits/vegetables?	Are you aware about the pesticides being used in fruits/vegetables?	If yes, what was the source of information?
What is your opinion regarding pesticide usage?	Are you aware about pesticide control measures?	Which one of the following do you opt for washing fruits and vegetables?	Number of washing sessions





**Manu Jose et al.,**



**Table 3. Results of Control Sample (without washing)**

Pesticide	Retention time	Peak height	Peak area	Concentration of pesticides (ppm)
Chlorpyrifos	30.248	55137	9145429	1.87
Ethion	35.632	1452	2417482	0.78
Fenvalerate	46.033, 46.559	9059, 6288	4737367	1.69

**Table 4. Statistical Analysis of control sample**

Pesticide	1	2	3	Mean	Standard deviation	RSD
Chlorpyrifos	1.861	1.87	1.879	1.87	0.009	0.481283
Ethion	0.777	0.78	0.788	0.78166667	0.005686241	0.727451
Fenvalerate	1.684	1.696	1.7	1.6933333	0.008326664	0.497132

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.4 – 0.7 which shows that there is no much deviation in the values obtained.

**Table 5. Results of grapes washed with normal water**

Pesticide	Retention time	Peak height	Peak area	Concentration of pesticides (ppm)
Chlorpyrifos	30.215	32769	8379505	1.73
Ethion	35.594	1326	1927401	0.63
Fenvalerate	45.984, 46.510	4464, 2669	4329734	1.56

**Table 6. Statistical analysis of grapes washed with normal water**

Pesticide	1	2	3	Mean	Standard deviation	RSD
Chlorpyrifos	1.72	1.736	1.742	1.732666	0.011372481	0.656357
Ethion	0.627	0.634	0.638	0.633	0.005567764	0.879584
Fenvalerate	1.571	1.568	1.55	1.563	0.011357817	0.726668

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.6-0.9 which shows that there is no much deviation in the values obtained.



Manu Jose *et al.*,**Table 7. Results of grapes washed with salt water**

Pesticide	Retention time	Peak height	Peak area	Concentration of pesticides (ppm)
Chlorpyrifos	30.208	49810	9006605	1.86
Ethion	35.587	1934	1981899	0.64
Fenvalerate	45.963, 46.483	7452, 5254	4550076	1.64

**Table 8. Statistical analysis of grapes washed with salt water**

Pesticide	1	2	3	Mean	Standard deviation	RSD
Chlorpyrifos	1.874	1.852	1.868	1.86466667	0.011372481	0.609894
Ethion	0.65	0.638	0.642	0.643333333	0.006110101	0.949757
Fenvalerate	1.65	1.645	1.634	1.643	0.008185353	0.498196

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.4-0.9 which shows that there is no much deviation in the values obtained

**Table 9. Results of grapes washed with vinegar**

Pesticide	Retention time	Peak height	Peak area	Concentration of pesticides (ppm)
Chlorpyrifos	30.223	39586	8527903	1.76
Ethion	35.607	2264	1992129	0.65
Fenvalerate	45.993, 46.522	6864, 4089	4917222	1.61

**Table 10. Statistical analysis of grapes washed with vinegar**

Pesticide	1	2	3	Mean	Standard deviation	RSD
Chlorpyrifos	1.759	1.772	1.763	1.76466667	0.008144528	0.461533
Ethion	0.65	0.649	0.658	0.652333333	0.004932883	0.756191
Fenvalerate	1.6	1.61	1.62	1.61	0.01	0.621118

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.4-0.8 which shows that there is no much deviation in the values obtained

**Table 11. Results of grapes washed with turmeric water**

Pesticide	Retention time	Peak height	Peak area	Concentration of pesticides (ppm)
Chlorpyrifos	30.239	42664	8786402	1.80
Ethion	35.623	1189	1942813	0.63
Fenvalerate	46.015, 46.538	6701, 4300	4362875	1.56







**Manu Jose et al.,**

**Table 12. Statistical analysis of grapes washed with turmeric water**

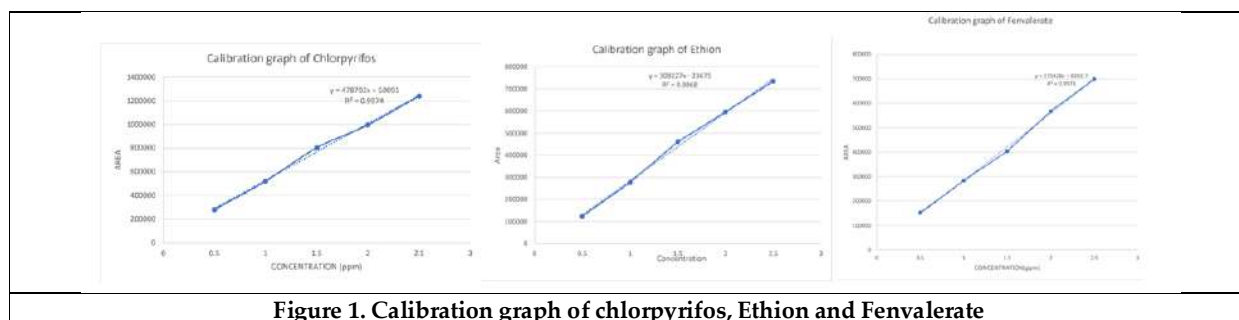
Pesticide	1	2	3	Mean	Standard deviation	RSD
Chlorpyrifos	1.79	1.8	1.81	1.8	0.01	0.555556
Ethion	0.629	0.63	0.635	0.631333	0.00321455	0.509168
Fenvalerate	1.562	1.57	1.56	1.564	0.005291503	0.338331

The statistical analysis of the above data of each pesticide gives the RSD within the range of 0.3-0.5 which shows that there is no much deviation in the values obtained.

**Table 13. Overall results of grapes washed by four methods**

Parameter: Pesticide analysis	Unit	Concentration of pesticides (ppm)					Detection limit
		Control	Normal water	Salt solution	Turmeric water	Vinegar	
Alachor	Mg/Kg	ND	ND	ND	ND	ND	0.01
Aldrin and dieldrin	Mg/Kg	ND	ND	ND	ND	ND	0.01
Azinphos methyl	Mg/Kg	ND	ND	ND	ND	ND	0.01
Chlorpyrifos	Mg/Kg	1.87	1.73	1.86	1.80	1.76	0.01
Bromopropylale	Mg/Kg	ND	ND	ND	ND	ND	0.01
Chlorfenvinphos	Mg/Kg	ND	ND	ND	ND	ND	0.01
Chlorpyriphos methyl	Mg/Kg	ND	ND	ND	ND	ND	0.01
Cypermethrin (and isomers)	Mg/Kg	ND	ND	ND	ND	ND	0.01
DDT	Mg/Kg	ND	ND	ND	ND	ND	0.01
Deltamethrin	Mg/Kg	ND	ND	ND	ND	ND	0.01
Dichlorvos	Mg/Kg	ND	ND	ND	ND	ND	0.01
Diazinon	Mg/Kg	ND	ND	ND	ND	ND	0.01
Fenvalarate	Mg/Kg	1.69	1.56	1.64	1.56	1.61	0.01
Fonofos	Mg/Kg	ND	ND	ND	ND	ND	0.01
Hexachlorocyclohexane isomers	Mg/Kg	ND	ND	ND	ND	ND	0.01
Lindane	Mg/Kg	ND	ND	ND	ND	ND	0.01
Malathion	Mg/Kg	ND	ND	ND	ND	ND	0.01
Parathion	Mg/Kg	ND	ND	ND	ND	ND	0.01
Parathion methyl	Mg/Kg	ND	ND	ND	ND	ND	0.01
Permethrin	Mg/Kg	ND	ND	ND	ND	ND	0.01
Piperonyl butoxide	Mg/Kg	ND	ND	ND	ND	ND	0.01
Ethion	Mg/Kg	0.78	0.63	0.64	0.63	0.65	0.01

ND: Not Detected

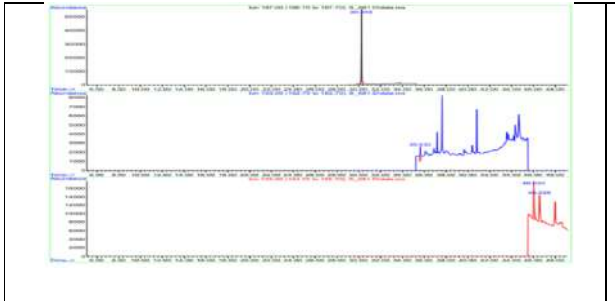


**Figure 1. Calibration graph of chlorpyrifos, Ethion and Fenvalerate**





**Manu Jose et al.,**



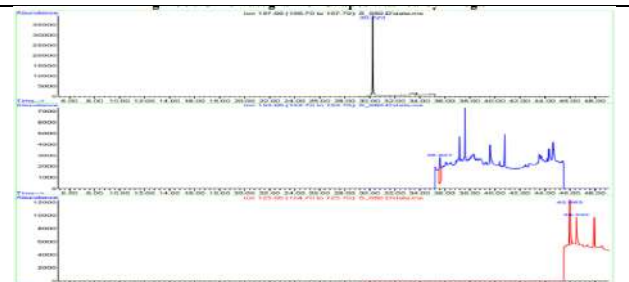
**Figure 2. Chromatogram of control sample**



**Figure 3. Chromatogram of grapes washed with normal water**



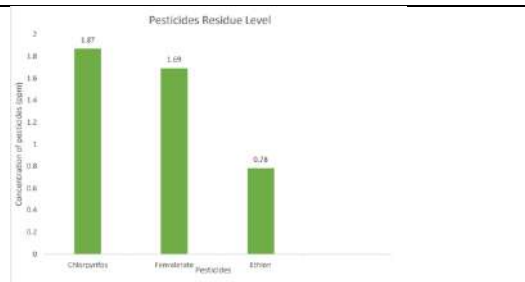
**Figure 4. Chromatogram of grapes washed with salt water**



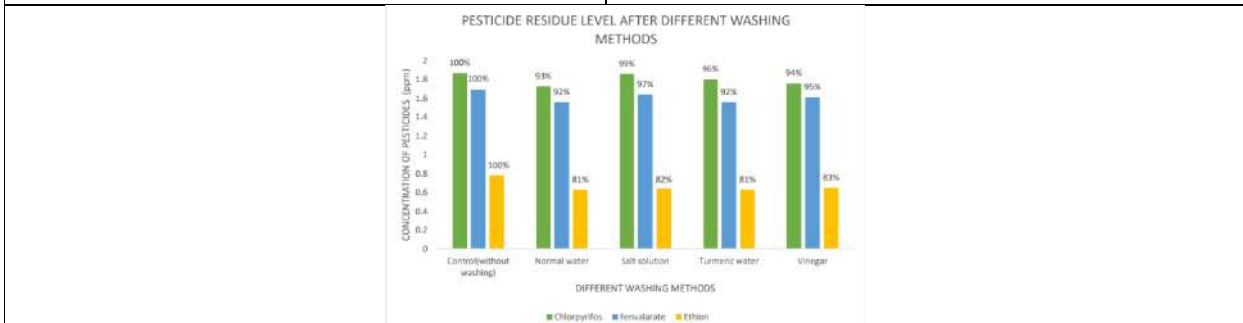
**Figure 5. Chromatogram of grapes washed with vinegar**



**Figure 6. Chromatogram of grapes washed with turmeric water**



**Figure 7. Graph on concentration of different pesticides**



**Figure 8. Graph on pesticide residue level after different washing methods**





## Multi-Object Manufacture with Multi-Trader Optimization of Fuzzy Inventory System Feasible Events along Credible Demand

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### ABSTRACT

Multi-object along multi-trader are achievable to widely shrinkage the expected total inventory costs as entire supply system. Because of producing product hiring dependent demand for multi-object along multi-trader credible actions bring about decrease total costs. Considering the unpredictability of different elements and target functions are indefinite in situation. The system is determined over the mean of interval method then the fuzzy equivalent problem is obtainable. A derivative method is recognized to attain for each object's optimal production quantity, shortage level and multi-object with multi-trader's minimum integrated expected total cost of the inventory system. The evaluation of the fuzzy multi-object along multi-trader inventory system through the crisp inventory system is concluded over arithmetical illustrations. Lastly, the graphical interpretation is offered to determine the suggested system. The effect establishes in the fuzzy multi-object along multi-trader inventory system is suitable to influential for the optimum outcomes.

**Keywords:** Fuzzy multi-object multi-trader inventory system, mean of interval method, Minimum total cost for multi-object multi-trader system, Derivative method, Optimal production quantity and shortage level for each object.





## INTRODUCTION

Inventory handling is the very crucial operators for a current industry. The dual focal of conclusions completed thru the Economic Production Quantity typical (i.e., how many objects to manufacture and what time to deliver the production order dependent demand) are stagnant broadly considered. This is the intention that in several firms existent are varies kind of product produces at the similar phase and joined with many traders. For illustration, a firm might control the production for hundreds of diverse objects along several traders and ensure constraint being demand dependent. Many modern inquiries observe have exposed that the joined manufacturer-trader inventory system has enhanced act than the non-combined inventory systems.

Pasandideh *et al.* (2010) conferred a multiple object inventory system along fault goods by allowing for rephrase and capacity constraints. Cárdenas-Barrón *et al.* (2014) established an unconnected multiple goods inventory typical through order quantity and distribution demand by economic constriction. Malik and Sarkar (2018) deliberated a multiple object constant evaluation inventory typical thru indeterminate demand, quality enhancement, setup price drop, and deviation regulate in lead time. Multiple good inventory prototypes among stock reliant on request are recognized in a fuzzy atmosphere. Goods are getting poorer at a stable price and are vended from varies exits in the municipal below a sole association presented by Ajoy Kumar Maiti (2020). Maximum of inventory achieves prime tactics designed at single objects, supposing a definite inventory approach pointed at solitary objects confirms not influence the expense on inventory and also the earnings of the organization. As an alternative to a single object, various firms or purchasers, or enterprises are encouraged to produce various objects in their manufacturing works and supply to several traders for advance profitable commercial environments. A further source of their inducement is to attract the traders to acquisition more than a few items in single manufacturer. Reflect multi-object multi-trader inventory system instead of sole-object single-trader is more suitable in actual existence environments.

Zadeh (1965) presented the idea of fuzzy collections may be observed as an attempt at developing a build of concepts and techniques for dealing in a systematic way with a type of imprecision objects that are not sharply well-defined. Chen (1985) presented a relationship function and the arithmetic operations of fuzzy number. An inventory typical designed aimed at objects using damaged level, lack of backorder over fuzzy situation investigated by Mahata and Goswami (2013). Priyan *et al.* (2015) assumed their demand rate is there searching near persuasive actions/trades group's enterprises, manufacture levels are uncertain then conceivable towards define by fuzzy triangular quantity. At that time defuzzified the combined total price used by signed distance process and the regular process is engaged to attain the prime results. Chakraborty *et al.* (2020) deliberated a hexagonal fuzzy number is utilised as a respected logic to comfort empathetic of imprecision evidence. Vithyadevi and Annadurai (2021) derived a combined inventory system through gathering cost decline reliant on lead interval in an unsure situation by hiring trapezoidal fuzzy number. The optimum result used for the established model is calculated by the Lagrangian method. Chen *et al.* (2002) handled a dual stage inventory model amongst multiple traders and single seller. Chan *et al.* (2010) considered a synchronized single-seller multi-consumer supply sequence typical by coordinating ordering and manufacture rotations over behind outflows that are created on the customer's order intermissions. Chen and Sarker (2016) discussed a joined optimization issue of manufacture inventory and selling rating choice for a sole producer multiple seller scheme of declining substances under just-in-time (JIT) distribution situation. Taleizadeh *et al.* (2011) handled a multiple purchaser multiple retailer supply sequence tricky is deliberated in which around the many objects, each purchaser has restricted volume to buying goods, and every retailer has storeroom restriction to accumulation goods.

Cardenas-Barron *et al.* (2014) derived inventory manufacture system designed to dual-level transfer sequence involving of one manufacturer and one trader with the demand is profound near persuasive actions of sales group's initiatives. Priyan and Uthayakumar (2015) reported a probability to imperfect retailer-purchaser combined inventory typical using the deliberation of worthy investigation faults on the purchaser's and structure price as role





**Vithyadevi and Annadurai**

of principal asset. Joint inventory typical is extended to conclude the prime results of conclusion changes after the seller towards the retailer in single production run. Sundara Rajan and Uthayakumar (2017) derived economic order size inventory typical which was measured subject to persuasive exertions. They found unique optimal replenishment schedule. Uthayakumar and Ganesh Kumar (2018) derived a combination of normal distributions and a combination of distribution free for more than a few goods by seller consumer joined tactic. Uthayakumar and Kumar (2019) handled a single-seller multi-customer stream chain system with several goods. The requirement of this stream sequence for every good is a stochastic adaptable. Rubono Setiawan *et.al.* (2021) investigated further accurate reasons such as arbitrary mandate, multiple products and multiple purchasers. In certainty, here definitely not assurances for whole formed goods are now flawless feature. Dharmendra Yadav *et al.* (2021) presented a stream sequence typical comprising single seller and single producer is inspected concerning the commercial feasibility. A defective multiple levels business procedure is measured at this point through a probabilistic worsening article.

The residual parts of the study accumulated as surveys. In Section 2, preliminary are offered. Section 3 introduces the notations and assumptions that are deliberated in the improvement of the production-inventory system for multi-object multi-trader. In Section 4, the crisp multi-object multi-trader inventory system is formulated. In Section 5, the fuzzy multi-object multi-trader inventory system is framed and examined. Section 6 illustrates the crisp and fuzzy multi-object multi-trader inventory system through numerical examples. Also in that segment, a compassion investigation is provided. Finally, Section 7 affords conclusion and future research directions.

**Preliminary**

**Defuzzification for hexagonal Fuzzy Number:** In Figure 1, the alpha ( $\alpha$ ) – cut method for  $\tilde{\alpha}$  is defined by  $\tilde{\alpha} = (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6)$  as a hexagonal fuzzy number. Then the defuzzification

$$P(\tilde{\alpha}) = \frac{\int_0^1 [L^{-1}(\alpha) + R^{-1}(\alpha)]d\alpha}{2},$$

$$P(\tilde{\alpha}) = \frac{\alpha_1 + \alpha_2 + \alpha_5 + \alpha_6}{4}. \tag{1}$$

**Notations and Assumptions**

We implement the succeeding notations and assumptions towards the progress of mathematical system.

**Notations**

- $y_{gt}$  Production quantity for  $g$  – th object of  $t$  – th trader,
- $\varphi_{gt}$  Trade group’s exertions for  $g$  – th object of  $t$  – th trader,
- $K_{gt}$  Shortage level for  $g$  – th object of  $t$  – th trader,
- $D_{gt}(\varphi_{gt})$  Demand proportion for  $g$  – th object of  $t$  – th trader,
- $D_{f_{gt}}$  The principal portion of the demand proportion for  $g$  – th object of  $t$  – th trader and that liberated of the trade group’s exertions,
- $D_{sgt}$  A scale factor of the secondary part of the demand, which differs with the trade group’s exertions for  $g$  – th object of  $t$  – th trader ( $\varphi_{gt}$ ),
- $n_{gt}$  Charge per unit effort of the trade group’s exertions for  $i$  – th object,
- $R_{gt}$  Production proportion for  $g$  – th object of  $t$  – th trader,
- $M_{gt}$  Manufacture’s setup cost for  $g$  – th object of  $t$  – th trader,







**Vithyadevi and Annadurai**

$O_{gt}$	Trader’s ordering cost for $g$ – th object of $t$ – th trader,
$H_{fgt}$	Manufactured object’s holding cost for $g$ – th object of $t$ – th trader per unit/unit period,
$C_{1gt}$	Retrieve cost for $g$ – th object of $t$ – th trader containing removal cost/unit,
$C_{3gt}$	Shortage cost for $g$ – th object of $t$ – th trader / unit /unit period,
$H_{rgt}$	Basic resource’s holding cost for $g$ – th object of $t$ – th trader /unit / unit period,
$r$	Flexibility factor,
$s_{gt}$	Checking ratio for $g$ – th object of $t$ – th trader / unit,
$C_{2gt}$	Checking cost for $g$ – th object of $t$ – th trader / unit,
$\theta$	Distribution parameter ( $0 \leq \theta \leq 1$ ) cost of trade group’s exertions,
$\zeta_{gt}$	Probability mass function for $g$ – th object of $t$ – th trader $f(\zeta_{gt})$ within faulty products proportionate probability,
$\delta_{gt}$	Probability mass function for $g$ – th object of $t$ – th trader $f(\zeta_{gt})$ within faultless products ( $\delta_{gt} = 1 - \zeta_{gt}$ ) proportionate probability,
$\mu_{0gt}$	Time at adjusting the shortages for $g$ – th object of $t$ – th trader,
$\mu_{1gt}$	Time span for satisfies the demand for $g$ – th object of $t$ – th trader,
$\Psi_{gt}$	Crisp integrated expected total cost for $g$ – th object of $t$ – th trader /unit quantity,
$\tilde{\Psi}_{gt}$	Fuzzy integrated expected total cost for $g$ – th object of $t$ – th trader / unit quantity,
$\Pi$	Integrated expected total cost for multi- object multi-trader in the crisp system (\$).
$\tilde{\Pi}$	Integrated expected total cost for multi- object multi-trader in the fuzzy system (\$).

**Assumptions**

1. A single supply sequence among the manufacturer and multi-trader for multi-object is deliberated addition to denoting a combined system, which produced optimum policies integrated to attain minimum cost for the supply sequence.
2. The manufacturer’s shortages for multi-object are unacceptable but if the trader’s shortage is acceptable then that is entirely backlogged.

**Model Construction**

In the manufacturing for multi-object multi-trader inventory system, that level of demand aimed at ending consumers remains specified through succeeding manifestation  $D_{gt}(\varphi_{gt}) = D_{fgt} + D_{sgt} \left(1 - \frac{1}{1 + \varphi_{gt}}\right)$  is associated with Cardenas-Barron and Sana (2014).

**Manufacturer’s Specific Total Cost for  $g$  – th Object of  $t$  – th trader:** The faultless-condition basic resources

inventory cost for  $g$  – th object of  $t$  – th trader is  $\frac{H_{rgt}}{2} \delta_{gt} y_{gt} T_{1gt} = \frac{H_{rgt}}{2R_{gt}} \delta_{gt}^2 y_{gt}^2$ . At that time the fault-





**Vithyadevi and Annadurai**

condition basic resources inventory cost for  $g$  – th object of  $t$  – th trader is  $H_{r_{gt}} \zeta_{gt} y_{gt} \frac{y_{gt}}{S_{gt}} = \frac{y_{gt}^2 H_{r_{gt}} \zeta_{gt}}{S_{gt}}$ .

Furthermore, the completed holding goods inventory cost for  $g$  – th object of  $t$  – th trader as  $\frac{H_{f_{gt}}}{2R_{gt}} \delta_{gt}^2 y_{gt}^2$  is

obtainable. The fault-condition basic resources removal cost for the manufacturer for  $g$  – th object of  $t$  – th trader is  $\zeta_{gt} y_{gt} C_{1_{gt}}$ . The checking cost for  $g$  – th object of  $t$  – th trader is  $y_{gt} C_{2_{gt}}$ . The manufacturer’s setup cost for  $g$  – th object of  $t$  – th trader is  $M_{gt}$ . The trade group’s exertions distribution cost for  $g$  – th object of  $t$  – th trader is  $n_{gt} \theta \phi_{gt}^r$ . Henceforth, the unit quantity’s expected total cost for  $g$  – th object of  $t$  – th trader, which is the summation of the above mentioned costs for manufacturer, is considered in this way:

$$\Psi_{M_{gt}} = \frac{M_{gt}}{y_{gt} E[\delta_{gt}]} + H_{r_{gt}} \left( \frac{y_{gt} E[\delta_{gt}]}{2R_{gt}} + \frac{y_{gt} E[\zeta_{gt}]}{s_{gt} E[\delta_{gt}]} \right) + \frac{H_{f_{gt}} y_{gt} E[\delta_{gt}]}{2R_{gt}} + \frac{E[\zeta_{gt}] C_{1_{gt}}}{E[\delta_{gt}]} + \frac{C_{2_{gt}}}{E[\delta_{gt}]} + \frac{\theta n_{gt} \phi_{gt}^r}{y_{gt} E[\delta_{gt}]} \quad (2)$$

**Trader’s Specific Total Cost for  $i$  – th object:** The holding cost for  $g$  – th object of  $t$  – th trader of the trader is  $\frac{1}{2} H_{f_{gt}} \{ \delta_{gt} y_{gt} - K_{gt} \} \mu_{1_{gt}} = \frac{1}{2D_{gt}} H_{f_{gt}} \{ \delta_{gt} y_{gt} - K_{gt} \}^2$ . The shortages cost for  $g$  – th object of  $t$  – th trader is

$\frac{1}{2} K_{gt} C_{3_{gt}} \mu_{0_{gt}} = \frac{1}{2D_{gt}} C_{3_{gt}} K_{gt}^2$ . The ordering cost for  $g$  – th object of  $t$  – th trader is  $O_{gt}$ , and then trade

group’s exertions distribution cost for  $g$  – th object of  $t$  – th trader is  $n_{gt} (1 - \theta) \phi_{gt}^r$ . Henceforth, we define the total expected cost for  $g$  – th object of  $t$  – th trader per unit quantity, which includes holding, ordering, sharing initiatives and shortage cost for  $g$  – th object of  $t$  – th trader is specified by

$$\Psi_{T_{gt}} = \frac{O_{gt}}{y_{gt} E[\delta_{gt}]} + H_{f_{gt}} \frac{\{ y_{gt} E[\delta_{gt}] - K_{gt} \}^2}{2D_{gt} y_{gt} E[\delta_{gt}]} + \frac{C_{3_{gt}} K_{gt}^2}{2D_{gt} y_{gt} E[\delta_{gt}]} + \frac{n_{gt} (1 - \theta) \phi_{gt}^r}{y_{gt} E[\delta_{gt}]} \quad (3)$$

**Integrated Expected Total Cost of the Manufacture and Trader**

Conferring to the assumptions (1) and (2) then the equations (2) to (3) termed above associated to, (Priyan et.al., 2015) the system’s integrated expected total cost for  $g$  – th object of  $t$  – th trader represented in  $\Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt}^r)$  reside of manufacturer’s expected total cost  $\Psi_{M_{gt}}$  and trader’s expected total  $\Psi_{T_{gt}}$ . The crisp integrated expected total cost for  $g$  – th object of  $t$  – th trader of the crisp system is mathematically expressed as

$$\Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt}^r) = \Psi_{M_{gt}} + \Psi_{T_{gt}} = \frac{M_{gt}}{y_{gt} \delta_{gt}} + H_{r_{gt}} \left( \frac{y_{gt} \delta_{gt}}{2R_{gt}} + \frac{y_{gt} \zeta_{gt}}{s_{gt} \delta_{gt}} \right) + \frac{H_{f_{gt}} y_{gt} \delta_{gt}}{2R_{gt}} + \frac{\zeta_{gt} C_{1_{gt}}}{\delta_{gt}} + \frac{C_{2_{gt}}}{\delta_{gt}} + \frac{\theta n_{gt} \phi_{gt}^r}{y_{gt} \delta_{gt}} + \frac{O_{gt}}{y_{gt} \delta_{gt}} + H_{f_{gt}} \frac{\{ y_{gt} \delta_{gt} - K_{gt} \}^2}{2D_{gt} y_{gt} \delta_{gt}} + \frac{C_{3_{gt}} K_{gt}^2}{2D_{gt} y_{gt} \delta_{gt}} + \frac{n_{gt} (1 - \theta) \phi_{gt}^r}{y_{gt} \delta_{gt}}, \quad ]$$





**Vithyadevi and Annadurai**

$$\Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt}) = \frac{M_{gt} + O_{gt}}{y_{gt}\delta_{gt}} + \frac{(H_{rgt} + H_{fgt})y_{gt}\delta_{gt}}{2R_{gt}} + \frac{H_{rgt}y_{gt}\zeta_{gt}}{s_{gt}\delta_{gt}} + \frac{(\zeta_{gt}C_{1gt} + C_{2gt})}{\delta_{gt}} + \frac{H_{fgt}}{2D_{gt}} \tag{4}$$

$$[y_{gt}\delta_{gt} + \frac{K_{gt}^2}{y_{gt}\delta_{gt}} - 2K_{gt}] + \frac{C_{3gt}K_{gt}^2}{2D_{gt}y_{gt}\delta_{gt}} + \frac{n_{gt}\varphi_{gt}^r}{y_{gt}\delta_{gt}}.$$

Here, the integrated expected total cost for  $g - th$  object of  $t - th$  trader  $\Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt})$  in which the terms  $\delta_{gt}$  and  $\zeta_{gt}$  in equation (4) are reformed by their expected values of  $E[\delta_{gt}]$  and  $E[\zeta_{gt}]$  correspondingly.

The integrated expected total cost for multi-object multi-trader  $\Pi_{gt}$  of the system in the crisp system given as

$$\Pi_{gt} = \sum_{g=1}^U [\Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt}) \times y_{gt}^C]. \tag{5}$$

We denote the crisp integrated expected total cost of  $t - th$  trader for all  $U$  objects by  $\Pi_t$ , that is  $\Pi_t = \sum_{g=1}^U \Pi_{gt}$

for  $t = 1, 2, \dots, V$  and the crisp integrated expected total cost of the entire system is

$$\Pi = \sum_{t=1}^V \Pi_t = \sum_{t=1}^V \sum_{g=1}^U \Pi_{gt},$$

$$\Pi = \sum_{t=1}^V \sum_{g=1}^U \left[ \left( \frac{M_{gt} + O_{gt}}{y_{gt}\delta_{gt}} + \frac{(H_{rgt} + H_{fgt})y_{gt}\delta_{gt}}{2R_{gt}} + \frac{H_{rgt}y_{gt}\zeta_{gt}}{s_{gt}\delta_{gt}} + \frac{(\zeta_{gt}C_{1gt} + C_{2gt})}{\delta_{gt}} + \frac{H_{fgt}}{2D_{gt}} [y_{gt}\delta_{gt} + \frac{K_{gt}^2}{y_{gt}\delta_{gt}} - 2K_{gt}] + \frac{C_{3gt}K_{gt}^2}{2D_{gt}y_{gt}\delta_{gt}} + \frac{n_{gt}\varphi_{gt}^r}{y_{gt}\delta_{gt}} \right) \times y_{gt}^C \right]. \tag{6}$$

**Inventory Model for Multi-Object in Crisp system**

In the initial case, we handle the multi-object manufacture with multi-trader inventory system with feasible events along credible demand in a crisp manner.

**Solution procedure:** At any case of organization, the goal is to minimize equation (4) and to determine optimum results for multi-object multi-trader that are production quantity for  $g - th$  object of  $t - th$  trader  $y_{gt}$  and shortage level for  $g - th$  object of  $t - th$  trader  $K_{gt}$ .

**Property: 1** As static  $y_{gt}$ ,  $\Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt})$  is convex in  $K_{gt}$ .

**Proof.** Partial derivatives of  $\Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt})$  with respect to  $K_{gt}$ , produce

$$\frac{\partial \Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt})}{\partial K_{gt}} = -\frac{H_{fgt}}{D_{gt}} + \frac{K_{gt}(H_{fgt} + C_{3gt})}{D_{gt}\delta_{gt}y_{gt}}, \tag{7}$$

and

$$\frac{\partial^2 \Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt})}{\partial K_{gt}^2} = \frac{(H_{fgt} + C_{3gt})}{D_{gt}\delta_{gt}y_{gt}} > 0. \tag{8}$$

And so, for static  $y_{gt}$ ,  $\Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt})$  is convex in  $K_{gt}$ .





**Vithyadevi and Annadurai**

Accordingly, by property 1  $\Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  is convex in  $K_{gt}$  for specified inputs  $y_{gt}$ . The distinctive optimum value of  $K_{gt}$  (indicated as  $K_{gt}^C$ ) can be find through equation (7) to zero as

$$K_{gt}^C = \left( \frac{H_{fgt}}{H_{fgt} + C_{3gt}} \right) \delta_{gt} y_{gt}^C. \tag{9}$$

**Property:2** As static  $K_{gt}$ , and  $\Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  is convex in  $y_{gt}$ .

**Proof.** Partial derivatives of  $\Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  with respect to  $y_{gt}$ , produce

$$\frac{\partial \Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})}{\partial y_{gt}} = -\frac{(M_{gt} + O_{gt})}{\delta_{gt} y_{gt}^2} + \frac{(H_{fgt} + H_{rgt}) \delta_{gt}}{2R_{gt}} + \frac{H_{rgt} \zeta_{gt}}{s_{gt} \delta_{gt}} + \frac{H_{fgt}}{2D_{gt}} \left( \delta_{gt} - \frac{K_{gt}^2}{\delta_{gt} y_{gt}^2} \right) - \frac{C_{3gt} K_{gt}^2}{2D_{gt} \delta_{gt} y_{gt}^2} - \frac{n_{gt} \phi_{gt}^r}{\delta_{gt} y_{gt}^2}. \tag{10}$$

Substitute equation (9) in (10) then we get,

$$\frac{\partial \Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})}{\partial y_{gt}} = -\frac{(M_{gt} + O_{gt})}{\delta_{gt} y_{gt}^2} + \frac{(H_{fgt} + H_{rgt}) \delta_{gt}}{2R_{gt}} + \frac{H_{rgt} \zeta_{gt}}{s_{gt} \delta_{gt}} + \frac{H_{fgt} \delta_{gt}}{2D_{gt}} - \frac{H_{fgt}^2 \delta_{gt}}{2D_{gt} (H_{fgt} + C_{3gt})} - \frac{n_{gt} \phi_{gt}^r}{\delta_{gt} y_{gt}^2}, \tag{11}$$

and

$$\frac{\partial^2 \Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})}{\partial y_{gt}^2} = \frac{2(M_{gt} + O_{gt} + n_{gt} \phi_{gt}^r)}{\delta_{gt} y_{gt}^3} > 0. \tag{12}$$

Therefore, for static  $K_{gt}$ ,  $\Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  is convex in  $y_{gt}$ .

Besides, by Property 2  $\Psi_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  is convex in  $y_{gt}$  to specified inputs  $K_{gt}$ . The unique optimum production quantity of  $y_{gt}$  (indicated as  $y_{gt}^C$ ) can be attained by equation (11) to zero as

$$y_{gt}^C = \left\{ \frac{2(M_{gt} + O_{gt} + n_{gt} \phi_{gt}^r)}{\delta_{gt}^2 \left( \frac{(H_{rgt} + H_{fgt})}{R_{gt}} + \frac{2H_{rgt} \zeta_{gt}}{\delta_{gt}^2 s_{gt}} + \frac{H_{fgt}}{D_{gt}} \left( 1 - \left( \frac{H_{fgt}}{C_{3gt} + H_{fgt}} \right) \right) \right)} \right\}^{1/2}. \tag{13}$$

**Inventory Model for Multi-Object Multi-Trader in Fuzzy System**

In the next case, we handle the multi-object manufacture with multi-trader inventory system with feasible events along credible demand in a fuzzy manner.

**Solution procedure:** In this segment, the fuzzy inventory model for multi-object multi-trader attainable by equation (4); i.e., through fuzzifying the system factors  $C_{1gt}, C_{2gt}, H_{rgt}, H_{gt}, s_{gt}, O_{gt}, M_{gt}, n_{gt}, R_{gt}$ .

The fuzzy form of the integrated expected total cost for  $g$  – th object of  $t$  – th trader is given as





**Vithyadevi and Annadurai**

$$\begin{aligned} \tilde{\Psi}_g(y_g, K_g, \phi_g) = & \tilde{\Psi}_{V_g} + \tilde{\Psi}_{I_g} = ((\tilde{M}_g \oplus \tilde{O}_g) \odot (y_g \otimes \delta_g)) \oplus (((\tilde{H}_{fg} \oplus \tilde{H}_{fg}) \otimes (\delta_g \otimes y_g)) \odot (2 \otimes \tilde{R}_g)) \oplus ((\tilde{H}_{fg} \otimes \\ & y_g \otimes \zeta_g) \odot (\delta_g \otimes \tilde{s}_g)) \oplus (((\tilde{C}_{1g} \otimes \zeta_g) \oplus \tilde{C}_{2g}) \odot \delta_g) \oplus (((\tilde{H}_{fg}) \odot (2 \otimes D_g)) \otimes (\delta_g \otimes y_g)) \oplus (K_g^2 \quad (14) \\ & \odot \delta_g \otimes y_g) \ominus (2 \otimes K_g)) \oplus ((C_{3g} \otimes K_g^2) \odot (2 \otimes D_g \otimes \delta_g \otimes y_g)) \oplus ((\tilde{n}_g \otimes \phi_g^r) \odot (\delta_g \otimes y_g)), \end{aligned}$$

Here  $\oplus, \odot, \otimes,$  and  $\ominus$  are the fuzzy arithmetical processes. Here, we adopt each parameter is nonnegative hexagonal fuzzy number comprising of six modules as:  $\tilde{C}_{1gt} = (C_{1gt1}, C_{1gt2}, C_{1gt3}, C_{1gt5}, C_{1gt6}),$   
 $\tilde{C}_{2gt} = (C_{2gt1}, C_{2gt2}, C_{2gt3}, C_{2gt4}, C_{2gt5}, C_{2gt6}), \tilde{H}_{rgt} = (H_{rgt1}, H_{rgt2}, H_{rgt3}, H_{rgt4}, H_{rgt5}, H_{rgt6}),$   
 $\tilde{H}_{fgt} = (H_{fgt1}, H_{fgt2}, H_{fgt3}, H_{fgt4}, H_{fgt5}, H_{fgt6}), \tilde{s}_g = (s_{gt1}, s_{gt2}, s_{gt3}, s_{gt4}, s_{gt5}, s_{gt6}),$   
 $\tilde{O}_g = (O_{gt1}, O_{gt2}, O_{gt3}, O_{gt4}, O_{gt5}, O_{gt6}), \tilde{M}_g = (M_{gt1}, M_{gt2}, M_{gt3}, M_{gt4}, M_{gt5}, M_{gt6}),$   
 $\tilde{n}_g = (n_{gt1}, n_{gt2}, n_{gt3}, n_{gt4}, n_{gt5}, n_{gt6}), \tilde{R}_g = (R_{gt1}, R_{gt2}, R_{gt3}, R_{gt4}, R_{gt5}, R_{gt6}).$

The fuzzy form of integrated expected total cost for  $g$  – th object of  $t$  – th trader  $\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  in equation (14) is given as

$$\begin{aligned} \tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt}) = & \frac{\tilde{M}_{gt} + \tilde{O}_{gt}}{y_{gt} \delta_{gt}} + \frac{(\tilde{H}_{rgt} + \tilde{H}_{fgt}) \delta_{gt} y_{gt}}{2 \tilde{R}_{gt}} + \frac{\tilde{H}_{rgt} \zeta_{gt} y_{gt}}{\delta_{gt} \tilde{s}_{gt}} + \frac{(\zeta_{gt} \tilde{C}_{1gt} + \tilde{C}_{2gt})}{\delta_{gt}} + \frac{\tilde{H}_{fgt}}{2 D_{gt}} \\ & [y_{gt} \delta_{gt} + \frac{K_{gt}^2}{\delta_{gt} y_{gt}} - 2 K_{gt}] + \frac{C_{3gt} K_{gt}^2}{2 D_{gt} \delta_{gt} y_{gt}} + \frac{\tilde{n}_{gt} \phi_{gt}^r}{\delta_{gt} y_{gt}}, \\ \tilde{\Psi}_g(y_g, K_g, \phi_g) = & \left( \frac{M_{g1} + O_{g1}}{\delta_g y_g} + \frac{(H_{fg1} + H_{rg1}) \delta_g y_g}{2 R_{g6}} + \frac{H_{rg1} \zeta_g y_g}{\delta_g s_{g6}} + \frac{(\zeta_g C_{1g1} + C_{2g1})}{\delta_g} + \frac{H_{fg1}}{2 D_g} [y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2 K_g] + \frac{C_{3g} K_g^2}{2 D_g \delta_g y_g} + \frac{\phi_g^r n_{g1}}{\delta_g y_g}, \right. \\ & \frac{M_{g2} + O_{g2}}{\delta_g y_g} + \frac{(H_{fg2} + H_{rg2}) \delta_g y_g}{2 R_{g5}} + \frac{H_{rg2} \zeta_g y_g}{\delta_g s_{g5}} + \frac{(\zeta_g C_{1g2} + C_{2g2})}{\delta_g} + \frac{H_{fg2}}{2 D_g} [y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2 K_g] + \frac{C_{3g} K_g^2}{2 D_g \delta_g y_g} + \frac{\phi_g^r n_{g2}}{\delta_g y_g}, \\ & \frac{M_{g3} + O_{g3}}{\delta_g y_g} + \frac{(H_{fg3} + H_{rg3}) \delta_g y_g}{2 R_{g4}} + \frac{H_{rg3} \zeta_g y_g}{\delta_g s_{g4}} + \frac{(\zeta_g C_{1g3} + C_{2g3})}{\delta_g} + \frac{H_{fg3}}{2 D_g} [y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2 K_g] + \frac{C_{3g} K_g^2}{2 D_g \delta_g y_g} + \frac{\phi_g^r n_{g3}}{\delta_g y_g}, \\ & \frac{M_{g4} + O_{g4}}{\delta_g y_g} + \frac{(H_{fg4} + H_{rg4}) \delta_g y_g}{2 R_{g3}} + \frac{H_{rg4} \zeta_g y_g}{\delta_g s_{g3}} + \frac{(\zeta_g C_{1g4} + C_{2g4})}{\delta_g} + \frac{H_{fg4}}{2 D_g} [y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2 K_g] + \frac{C_{3g} K_g^2}{2 D_g \delta_g y_g} + \frac{\phi_g^r n_{g4}}{\delta_g y_g}, \\ & \frac{M_{g5} + O_{g5}}{\delta_g y_g} + \frac{(H_{fg5} + H_{rg5}) \delta_g y_g}{2 R_{g2}} + \frac{H_{rg5} \zeta_g y_g}{\delta_g s_{g2}} + \frac{(\zeta_g C_{1g5} + C_{2g5})}{\delta_g} + \frac{H_{fg5}}{2 D_g} [y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2 K_g] + \frac{C_{3g} K_g^2}{2 D_g \delta_g y_g} + \frac{\phi_g^r n_{g5}}{\delta_g y_g}, \\ & \left. \frac{M_{g6} + O_{g6}}{\delta_g y_g} + \frac{(H_{fg6} + H_{rg6}) \delta_g y_g}{2 R_{g1}} + \frac{H_{rg6} \zeta_g y_g}{\delta_g s_{g1}} + \frac{(\zeta_g C_{1g6} + C_{2g6})}{\delta_g} + \frac{H_{fg6}}{2 D_g} [y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2 K_g] + \frac{C_{3g} K_g^2}{2 D_g \delta_g y_g} + \frac{\phi_g^r n_{g6}}{\delta_g y_g} \right) \quad (15) \end{aligned}$$

We defuzzify  $\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  by equation (1) and acquire the  $(\alpha)$  – cut method of  $\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt})$  as







Vithyadevi and Annadurai

$$\begin{aligned}
 P(\tilde{\Psi}(y, K, \phi)) = & \left( \frac{1}{4} \left( \frac{M_{g1} + O_{g1}}{\delta_g y_g} + \frac{(H_{fg1} + H_{fg2}) \delta_g y_g}{2R_{g6}} + \frac{H_{fg1} \zeta_g y_g}{\delta_g s_{g6}} + \frac{(\zeta_g C_{1g1} + C_{2g1})}{\delta_g} + \frac{H_{fg1}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g1}}{\delta_g y_g} \right) \right. \\
 & + \frac{1}{4} \left( \frac{M_{g2} + O_{g2}}{\delta_g y_g} + \frac{(H_{fg2} + H_{fg2}) \delta_g y_g}{2R_{g5}} + \frac{H_{fg2} \zeta_g y_g}{\delta_g s_{g5}} + \frac{(\zeta_g C_{1g2} + C_{2g2})}{\delta_g} + \frac{H_{fg2}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g2}}{\delta_g y_g} \right) \\
 & + \frac{1}{4} \left( \frac{M_{g5} + O_{g5}}{\delta_g y_g} + \frac{(H_{fg5} + H_{fg5}) \delta_g y_g}{2R_{g2}} + \frac{H_{fg5} \zeta_g y_g}{\delta_g s_{g2}} + \frac{(\zeta_g C_{1g5} + C_{2g5})}{\delta_g} + \frac{H_{fg5}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g5}}{\delta_g y_g} \right) \\
 & \left. + \frac{1}{4} \left( \frac{M_{g6} + O_{g6}}{\delta_g y_g} + \frac{(H_{fg6} + H_{fg6}) \delta_g y_g}{2R_{g1}} + \frac{H_{fg6} \zeta_g y_g}{\delta_g s_{g1}} + \frac{(\zeta_g C_{1g6} + C_{2g6})}{\delta_g} + \frac{H_{fg6}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g6}}{\delta_g y_g} \right) \right) \tag{16}
 \end{aligned}$$

where  $0 < y_{gt}$  and  $0 < K_{gt}$ .

The fuzzy system of the integrated expected total cost  $\tilde{\Pi}_{gt}$  for multi- object in equation (17) is specified as

$$\tilde{\Pi}_{gt} = \sum_{g=1}^U [y_{gt}^F \times P(\tilde{\Psi}_{gt}(y_{gt}^*, K_{gt}^*, \phi_{gt}))]. \tag{17}$$

We denote the fuzzy integrated expected total cost of  $t$ -th trader for all  $U$  objects by  $\tilde{\Pi}_t$ , that is  $\tilde{\Pi}_t = \sum_{g=1}^U \tilde{\Pi}_{gt}$  for

$t = 1, 2, \dots, V$  and the fuzzy integrated expected total cost of the entire system is

$$\begin{aligned}
 \tilde{\Pi} = & \sum_{t=1}^V \tilde{\Pi}_t = \sum_{t=1}^V \sum_{g=1}^U \tilde{\Pi}_{gt}, \\
 \tilde{\Pi} = & \sum_{t=1}^V \sum_{g=1}^U \left[ y_{gt}^F \times \left( \frac{1}{4} \left( \frac{M_{g1} + O_{g1}}{\delta_g y_g} + \frac{(H_{fg1} + H_{fg1}) \delta_g y_g}{2R_{g6}} + \frac{H_{fg1} \zeta_g y_g}{\delta_g s_{g6}} + \frac{(\zeta_g C_{1g1} + C_{2g1})}{\delta_g} + \frac{H_{fg1}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g1}}{\delta_g y_g} \right) \right. \right. \\
 & + \frac{1}{4} \left( \frac{M_{g2} + O_{g2}}{\delta_g y_g} + \frac{(H_{fg2} + H_{fg2}) \delta_g y_g}{2R_{g5}} + \frac{H_{fg2} \zeta_g y_g}{\delta_g s_{g5}} + \frac{(\zeta_g C_{1g2} + C_{2g2})}{\delta_g} + \frac{H_{fg2}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g2}}{\delta_g y_g} \right) \\
 & + \frac{1}{4} \left( \frac{M_{g5} + O_{g5}}{\delta_g y_g} + \frac{(H_{fg5} + H_{fg5}) \delta_g y_g}{2R_{g2}} + \frac{H_{fg5} \zeta_g y_g}{\delta_g s_{g2}} + \frac{(\zeta_g C_{1g5} + C_{2g5})}{\delta_g} + \frac{H_{fg5}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g5}}{\delta_g y_g} \right) \\
 & \left. \left. + \frac{1}{4} \left( \frac{M_{g6} + O_{g6}}{\delta_g y_g} + \frac{(H_{fg6} + H_{fg6}) \delta_g y_g}{2R_{g1}} + \frac{H_{fg6} \zeta_g y_g}{\delta_g s_{g1}} + \frac{(\zeta_g C_{1g6} + C_{2g6})}{\delta_g} + \frac{H_{fg6}}{2D_g} \left[ y_g \delta_g + \frac{K_g^2}{y_g \delta_g} - 2K_g \right] + \frac{C_{3g} K_g^2}{2D_g \delta_g y_g} + \frac{\phi_g^r n_{g6}}{\delta_g y_g} \right) \right) \right]. \tag{18}
 \end{aligned}$$

When defuzzified fuzzy integrated expected total cost for  $g$ -th object of  $t$ -th trader  $P(\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt}))$  is minimized, the fuzzy production quantity for  $g$ -th object of  $t$ -th trader  $y_{gt}$  (represented as  $y_{gt}^F$ ) and  $g$ -th object of  $t$ -th trader  $K_{gt}$  (represented as  $K_{gt}^F$ ) is obtained. The minimization of defuzzified fuzzy integrated expected total cost for  $g$ -th object of  $t$ -th trader  $P(\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt}))$  is derived from the solution of the first order partial derivative of the equation (16) with respect to  $K_{gt}$  and  $y_{gt}$  is





**Vithyadevi and Annadurai**

$$\frac{\partial P(\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt}))}{\partial K_{gt}} = \frac{1}{4} \left[ \frac{H_{fgt1}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} + \frac{C_{3gt}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} - \frac{H_{fgt6}}{D_{gt}} \right] + \left[ \frac{H_{fgt2}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} + \frac{C_{3gt}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} - \frac{H_{fgt5}}{D_{gt}} \right] + \left[ \frac{H_{fgt5}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} + \frac{C_{3gt}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} - \frac{H_{fgt2}}{D_{gt}} \right] + \left[ \frac{H_{fgt6}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} + \frac{C_{3gt}K_{gt}}{D_{gt}\delta_{gt}y_{gt}} - \frac{H_{fgt1}}{D_{gt}} \right] = 0, \tag{19}$$

$$\frac{\partial P(\tilde{\Psi}_{gt})}{\partial y_{gt}} = \frac{1}{4} \left( \left[ \frac{(M_{gt6} + O_{gt6})}{\delta_{gt}y_{gt}^2} + \frac{(H_{fgt1} + H_{rgt1})\delta_{gt}}{2R_{gt6}} + \frac{H_{rgt1}\zeta_{gt}}{s_{gt6}\delta_{gt}} + \frac{H_{fgt1}\delta_{gt}}{2D_{gt}} - \frac{H_{fgt6}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{C_{3gt}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{n_{gt6}\phi_{gt}^r}{\delta_{gt}y_{gt}^2} \right] + \left[ \frac{(M_{gt5} + O_{gt5})}{\delta_{gt}y_{gt}^2} + \frac{(H_{fgt2} + H_{rgt2})\delta_{gt}}{2R_{gt5}} + \frac{H_{rgt2}\zeta_{gt}}{s_{gt5}\delta_{gt}} + \frac{H_{fgt2}\delta_{gt}}{2D_{gt}} - \frac{H_{fgt5}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{C_{3gt}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{n_{gt5}\phi_{gt}^r}{\delta_{gt}y_{gt}^2} \right] + \left[ \frac{(M_{gt2} + O_{gt2})}{\delta_{gt}y_{gt}^2} + \frac{(H_{fgt5} + H_{rgt5})\delta_{gt}}{2R_{gt2}} + \frac{H_{rgt5}\zeta_{gt}}{s_{gt2}\delta_{gt}} + \frac{H_{fgt5}\delta_{gt}}{2D_{gt}} - \frac{H_{fgt2}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{C_{3gt}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{n_{gt2}\phi_{gt}^r}{\delta_{gt}y_{gt}^2} \right] + \left[ \frac{(M_{gt1} + O_{gt1})}{\delta_{gt}y_{gt}^2} + \frac{(H_{fgt6} + H_{rgt6})\delta_{gt}}{2R_{gt1}} + \frac{H_{rgt6}\zeta_{gt}}{s_{gt1}\delta_{gt}} + \frac{H_{fgt6}\delta_{gt}}{2D_{gt}} - \frac{H_{fgt1}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{C_{3gt}K_{gt}^2}{2D_{gt}\delta_{gt}y_{gt}^2} - \frac{n_{gt1}\phi_{gt}^r}{\delta_{gt}y_{gt}^2} \right] \right) = 0 \tag{20}$$

On simplification, the fuzzy optimal shortage level for  $g$  – th object of  $t$  – th trader and fuzzy optimal production quantities for  $g$  – th object of  $t$  – th trader  $K_{gt}$  and  $y_{gt}$  are given by

$$y_{gt}^F = \left\{ \frac{[S_{gt}] + [T_{gt}] + [U_{gt}] + V_{gt}}{\delta_{gt}^2 (E_{gt} + F_{gt} + G_{gt} + H_{gt})} \right\}^{1/2}, \tag{21}$$

$$K_{gt}^F = K_{gt} = \left( \frac{H_{fgt6}\delta_{gt}y_{gt} + H_{fgt5}\delta_{gt}y_{gt} + H_{fgt2}\delta_{gt}y_{gt} + H_{fgt1}\delta_{gt}y_{gt}}{(C_{3gt} + H_{fgt1}) + (C_{3gt} + H_{fgt2}) + (C_{3gt} + H_{fgt5}) + (C_{3gt} + H_{fgt6})} \right), \tag{22}$$

where,  $S_{gt} = 2(M_{gt6} + O_{gt6} + n_{gt6}\phi_{gt}^r)$ ,  $T_{gt} = 2(M_{gt5} + O_{gt5} + n_{gt5}\phi_{gt}^r)$ ,  $U_{gt} = 2(M_{gt2} + O_{gt2} + n_{gt2}\phi_{gt}^r)$ ,

$$V_{gt} = 2(M_{gt1} + O_{gt1} + n_{gt1}\phi_{gt}^r), E_{gt} = \frac{(H_{rgt1} + H_{fgt1})}{R_{gt6}} + \frac{2H_{rgt1}\zeta_{gt}}{s_{gt6}\delta_{gt}^2} + \frac{H_{fgt1}}{D_{gt}} \left( 1 - \left( \frac{H_{fgt1}}{H_{fgt6} + C_{3gt}} \right) \right),$$

$$F_{gt} = \frac{(H_{rgt2} + H_{fgt2})}{R_{gt5}} + \frac{2H_{rgt2}\zeta_{gt}}{s_{gt5}\delta_{gt}^2} + \frac{H_{fgt2}}{D_{gt}} \left( 1 - \left( \frac{H_{fgt2}}{H_{fgt5} + C_{3gt}} \right) \right),$$

$$G_{gt} = \frac{(H_{rgt5} + H_{fgt5})}{R_{gt2}} + \frac{2H_{rgt5}\zeta_{gt}}{s_{gt2}\delta_{gt}^2} + \frac{H_{fgt5}}{D_{gt}} \left( 1 - \left( \frac{H_{fgt5}}{H_{fgt2} + C_{3gt}} \right) \right),$$

$$H_i = \frac{(H_{rgt6} + H_{fgt6})}{R_{gt1}} + \frac{2H_{rgt6}\zeta_{gt}}{s_{gt1}\delta_{gt}^2}$$

$$+ \frac{H_{fgt6}}{D_{gt}} \left( 1 - \left( \frac{H_{fgt6}}{H_{fgt1} + C_{3gt}} \right) \right),$$

The optimum integrated expected total cost for  $g$  – th object of  $t$  – th trader  $P(\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \phi_{gt}))$  is achieved through apply the equations (21) and (22) into equation (16).





**Vithyadevi and Annadurai**

The succeeding algorithm is used to determine the optimum solutions for  $g$ –th object of  $t$ –th trader  $y_{gt}^C, K_{gt}^C, y_{gt}^F, K_{gt}^F$  and minimum integrated expected total cost for the projected multi-object multi-trader fuzzy system.

**Algorithm**

**Step 1.** Using derivative method, find  $y_{gt}^C, K_{gt}^C$  then calculate  $y_{gt}^C, K_{gt}^C$  by equations (13) and (9) respectively.

**Step 2.** Determine the consequent solutions for  $g$ –th object of  $t$ –th trader  $\Psi_{gt}(y_{gt}, K_{gt}, \varphi_{gt})$ . Apply the equations (13) and (9) into equation (4).

**Step 3.** Compute  $\Pi_{gt}, \tilde{\Pi}$  from equations (5) and (6) correspondingly.

**Step 4.** Using  $(\alpha)$ –cut and derivative method find  $y_{gt}^F, K_{gt}^F$  then calculate  $y_{gt}^F, K_{gt}^F$  by equations (21) and (22) respectively.

**Step 5.** Determine the consequent solutions for  $g$ –th object of  $t$ –th trader  $P(\tilde{\Psi}_{gt}(y_{gt}, K_{gt}, \varphi_{gt}))$ . Apply the equations (21) and (22) into equation (16).

**Step 6.** Compute  $\tilde{\Pi}_{gt}, \tilde{\Pi}$  from equations (17) and (18) correspondingly.

**Step 7.** Compare the multi-object multi-trader integrated total cost for the system and the optimal production quantity, shortage level for  $g$ –th object of  $t$ –th trader and in crisp model and fuzzy model. If  $y_{gt}^C > y_{gt}^F, K_{gt}^C > K_{gt}^F$  and  $\Pi_{gt} > \tilde{\Pi}_{gt}$  then the proposed fuzzy model is finest to find the optimal solutions, else  $y_{gt}^C < y_{gt}^F, K_{gt}^C < K_{gt}^F$  and  $\Pi_{gt} < \tilde{\Pi}_{gt}$  then the crisp model is the finest to find the optimal solutions.

**Step 8.** Compare the optimal production quantity, shortage level for  $g$ –th object of  $t$ –th trader, integrated expected total cost for multi-object multi-trader system obtained from both crisp model and the fuzzy model with their savings.

**Numerical Analysis and Graphical Interpretation**

**Numerical analysis:** To demonstrate the result technique for crisp system, we better deliberate the system through preliminary input taken in Priyan et.al. (2015) and remaining input is made-up permitting to the system. The results of this illustration are acquired by utilizing MatLab software.

Let us consider the integrated multi-object multi-trader inventory system for three objects and three traders. That is  $U = V = 3$  and identical parameters are  $r = 1, \theta = 50\%$ , and  $\zeta_{gt}$  is a uniformly distributed random variable,

$$U(\alpha_{gt}, \beta_{gt}) = (0, 0.04), \quad \text{where} \quad E(\zeta_{gt}) = (\alpha_{gt} + \beta_{gt}) / 2 = 0.02 \quad \text{and} \quad E[(1 - \zeta_{gt})^2] = \frac{(\alpha_{gt}^2 + \beta_{gt}^2 + \alpha_{gt}\beta_{gt})}{3} + 1 - \alpha_{gt} - \beta_{gt} = 0.9604$$

in place of entire  $g = 1, 2, 3$  also  $t = 1, 2, 3$ . Now Table 1 certain

factors are specified and it is equal for entire traders. Particular factors are specified in Table 2 comprises demand of every item for all traders. The fuzzy inputs are in Table 3.

Using algorithm the crisp and fuzzy results are depicted in Table 4-6, when trader’s various demand rates are  $D_{g1} = (158, 105, 132), D_{g2} = (160, 110, 135), D_{g3} = (159, 158, 162)$  and their respective optimum outputs. We get the optimal production quantity for each object  $y_{gt}^C, y_{gt}^F$ , shortage level for each object  $K_{gt}^C, K_{gt}^F$  and minimum integrated expected total cost for multi-object multi-trader system  $\Pi, \tilde{\Pi}$ .



**Vithyadevi and Annadurai**

Also summarized for the each object's optimal production quantity, shortage level and minimum integrated expected total cost for multi-object multi-trader saving percentages are presented in Table 7. Our outcomes specify that the fuzzy multi-object multi-trader case considerably vary from the results of the crisp multi-object multi-trader system and this is offered.

**Graphical Interpretation**

Graphical interpretation of the integrated expected total cost, against the diverse quantities of demand is associated together in the fuzzy and crisp multi-object multi-trader systems as shown in Figure 2. It is detected that the integrated expected total cost are positively enhanced in the fuzzy multi-object multi-trader inventory system compared to the crisp inventory system.

**CONCLUSION**

Multi-object multi-trader for two-level integrated inventory model with feasible events credible demand is established in together crisp and fuzzy situations. In the fuzzy situation, all correlated inventory factors are presumed to be hexagonal fuzzy quantities. For defuzzification, the alpha ( $\alpha$ ) – cut process is hired to assess the minimum integrated expected total cost for multi-object multi-trader. The derivative technique is utilized to acquire for the each object's optimum production quantity, shortage level and then obtain the integrated expected total cost the inventory system. Since the statistic and graphical observation of conclusion, the prices of inventory supply chain decreasing. After comparing both the multi-object multi-trader of the fuzzy and crisp system, it is perceived that the fuzzy inventory system for multi-object multi-trader is enhanced than the crisp inventory system for multi-object multi-trader. Hence, the research representations that in the model, fuzzy system delivered marketable profit-making model for minimum integrated expected total for multi-object multi-trader. For future investigation on this problem, we would consider multi – objects multi-trader in this system to study the capital with capacity constraints. Another study link can be to examine the inventory system through power demand patterns, supposing that stock lacks are vanishes.

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**Vithyadevi and Annadurai**

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**Table 1: Common trader data for all objects**

Object $g$	$H_{rgt}$	$H_{fgt}$	$C_{1gt}$	$C_{2gt}$	$s_{gt}$	$O_{gt}$	$M_{gt}$	$n_{gt}$	$R_{gt}$	$C_{3gt}$
1	7.5	4.5	22.5	0.75	262800	150	600	2250	225	37.5
2	5	3	15	0.5	175200	100	400	1500	150	25
3	6.25	3.75	18.75	0.625	219000	125	500	1875	187.5	31.25

**Table 2: Demand of  $g$ -th object for the  $t$ -th trader**

$D_{gt}$	$t = 1$	$t = 2$	$t = 3$
$g = 1, 2, 3$	(158, 105, 132)	(160, 110, 135)	(159, 158, 162)







**Vithyadevi and Annadurai**

**Table 3: Common trader data  $t$  for all items**

	$g = 1, 2, 3$
$H_{rgt}$	$H_{rgt1} = (3, 2, 2.5), H_{rgt2} = (6, 4, 5), H_{rgt3} = (6.75, 4.5, 5.625), H_{rgt4} = (8.25, 5.5, 6.875),$ $H_{rgt5} = (9, 6, 7.5), H_{rgt6} = (12, 8, 10).$
$H_{fgt}$	$H_{fgt1} = (2.25, 1.5, 1.875), H_{fgt2} = (3.75, 2.5, 3.125), H_{fgt3} = (4.2, 2.8, 3.5), H_{fgt4} = (4.8, 3.2,$ $4), H_{fgt5} = (5.25, 3.5, 4.375), H_{fgt6} = (6.75, 4.5, 5.625).$
$C_{1gt}$	$C_{1gt1} = (9, 6, 7.5), C_{1gt2} = (18, 12, 15), C_{1gt3} = (21, 14, 17.5), C_{1gt4} = (24, 16, 20), C_{1gt5} =$ $(27, 18, 22.5), C_{1gt6} = (36, 24, 30).$
$C_{2gt}$	$C_{2gt1} = (0.3, 0.2, 0.25), C_{2gt2} = (0.6, 0.4, 0.5), C_{2gt3} = (0.675, 0.45, 0.5625), C_{2gt4} = (0.825,$ $0.55, 0.6875), C_{2gt5} = (0.9, 0.6, 0.75), C_{2gt6} = (1.2, 0.8, 1).$
$S_{gt}$	$S_{gt1} = (234900, 156600, 195750), S_{gt2} = (253500, 169000, 211250), S_{gt3} = (256500, 171000, 213750),$ $S_{gt4} = (269100, 179400, 224250), S_{gt5} = (272100, 181400, 226750), S_{gt6} = (290700, 193800, 242250).$
$O_{gt}$	$O_{gt1} = (60, 40, 50), O_{gt2} = (120, 80, 100), O_{gt3} = (135, 90, 112.5), O_{gt4} = (165, 110, 137.5),$ $O_{gt5} = (180, 120, 150), O_{gt6} = (240, 160, 200).$
$M_{gt}$	$M_{gt1} = (285, 190, 237.5), M_{gt2} = (495, 330, 412.5), M_{gt3} = (525, 350, 437.5), M_{gt4} = (0.1155,$ $0.105, 0.12075, 0.11025), M_{gt5} = (0.1155, 0.105, 0.12075, 0.11025), M_{gt6} = (0.121, 0.11, 0.1265, 0.1155).$
$n_{gt}$	$n_{gt1} = (900, 600, 750), n_{gt2} = (1800, 1200, 1500), n_{gt3} = (2100, 1400, 1750), n_{gt4} = (3000, 2000,$ $2500), n_{gt5} = (2700, 1800, 2250), n_{gt6} = (3600, 2400, 3000).$
$R_{gt}$	$R_{gt1} = (90, 60, 75), R_{gt2} = (180, 120, 150), R_{gt3} = (210, 140, 175), R_{gt4} = (300, 200, 250),$ $R_{gt5} = (270, 180, 225), R_{gt6} = (360, 240, 300).$

**Table 4: Crisp and Fuzzy Optimal solutions for Multi-object with varies  $D_{gt}$ .**

Parameter	Number of object $g = 1, 2, 3;$		Number of object $g = 1, 2, 3;$	
	Crisp Model		Fuzzy Model	
Trader-1	$y_{gt}^C$	(281.6, 229.8, 257.2)	$y_{gt}^F$	(238.9, 195.0, 218.2)
$D_{g1} =$	$K_{gt}^C$	(29.6, 24.1, 27.0)	$K_{gt}^F$	(25.1, 20.5, 22.9)
(158, 105,	$\Psi_{gt} \times y_{gt}^C$	(6467.3, 4269.3, 5364.5)	$\tilde{\Psi}_{gt} \times y_{gt}^F$	(6429.6, 4250.5, 5336.8)



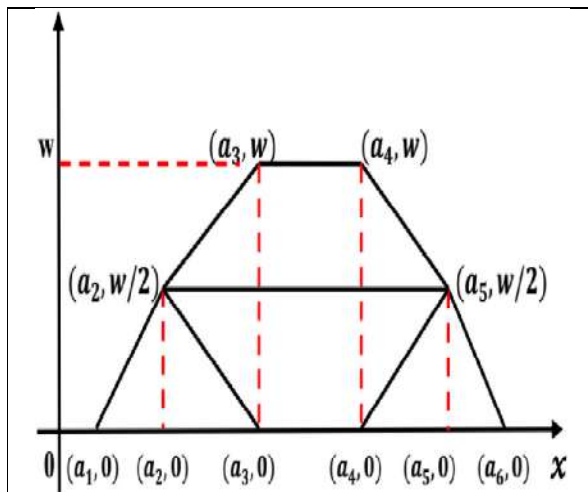


**Vithyadevi and Annadurai**

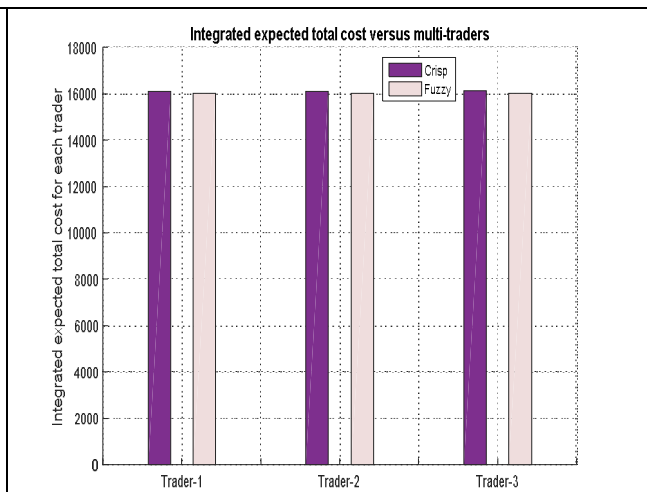
132).	$\Pi_{g1}$	<b>16101.0</b>	$\tilde{\Pi}_{g1}$	<b>16017.0</b>
Trader-2 $D_{g2} =$ (160, 110, 135).	$y_{gt}^C$	(282.2, 231.5, 258.1)	$y_{gt}^F$	(239.2, 196.0, 218.7)
	$K_{gt}^C$	(29.6, 24.3, 27.1)	$K_{gt}^F$	(25.1, 20.6, 23.0)
	$\Psi_{gt} \times y_{gt}^C$	(6468.0, 4270.6, 5365.4)	$\tilde{\Psi}_{gt} \times y_{gt}^F$	(6429.8, 4251.0, 5337.1)
	$\Pi_{g2}$	<b>16104.0</b>	$\tilde{\Pi}_{g2}$	<b>16018.0</b>
Trader-3 $D_{g3} =$ (159, 158, 162).	$y_{gt}^C$	(281.9, 243.4, 265.2)	$y_{gt}^F$	(239.1, 202.9, 222.9)
	$K_{gt}^C$	(29.6, 25.6, 27.9)	$K_{gt}^F$	(25.1, 21.3, 23.4)
	$\Psi_{gt} \times y_{gt}^C$	(6467.7, 4280.3, 5372.7)	$\tilde{\Psi}_{gt} \times y_{gt}^F$	(6429.7, 4254.3, 5339.8)
	$\Pi_{g3}$	<b>16121.0</b>	$\tilde{\Pi}_{g3}$	<b>16024.0</b>
	$\Pi$	<b>48326.0</b>	$\tilde{\Pi}$	<b>48059.0</b>

**Table 5: Summary of Crisp and Fuzzy Optimal solutions**

Demand	Savings (%) Optimal production quantity for each object	Savings (%) Optimal shortage level for each object	Savings (%) Integrated expected total cost for multi-object
Trader-1	(15.2, 15.2, 15.2)	(15.2, 15.2, 15.2)	0.5
Trader-2	(15.2, 15.3, 15.3)	(15.2, 15.3, 15.3)	0.5
Trader-3	(15.2, 16.6, 16.0)	(15.2, 16.6, 16.0)	0.6



**Figure 1: The generalized hexagonal fuzzy number**  
 $\tilde{\alpha} = (\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6).$



**Figure 2: Integrated expected total cost against multi-trader.**





## Very Irredundant Excellence in Fuzzy Graphs

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### ABSTRACT

In a social network, we may exchange any node inside the network by a node in outside the network, gives a better status in the form of a new group. Such a situation can be modelled as a set  $S$  of vertices in the graph  $G$  representing the social network such that for every  $y \in V(G)$  there exists  $x \in S$  such that the new social group  $S = (S \setminus \{x\}) \cup \{y\}$  has the same property as that of  $S$  and is possibly better in terms of external connections as well as its internal organization. Such a type of set  $S$  is called fuzzy very irredundant set.

**Keywords:** Fuzzy irredundant set, Fuzzy very irredundant set, very *irf* excellent-fixed, Totally very *irf* excellent

Subject classification: 05C72

### INTRODUCTION

Terasa W. Haynes *et. al.*[5], introduced the concept of irredundance in graphs. A subset  $S$  of  $V(G)$  is called an irredundant set of  $G$  if for every vertex  $u \in S$   $pn[u, S] \neq \emptyset$ . The minimum (maximum) cardinality of a maximal irredundant set of  $G$  is called the irredundance number of  $G$  (upper irredundance number of  $G$ ) and is denoted by  $ir(G)$  ( $IR(G)$ ). Later the concept of irredundance was extended to fuzzy irredundance. Fuzzy irredundant sets and irredundance are introduced by A.Nagoorgani and P.Vadivel [4]. Also P. Nithya, K. M. Dharmalingam [9] was





**Dharmalingam et al.,**

discussed about Very Excellent Domination in Fuzzy graphs. This paper proposes irredundance excellence and very irredundant excellence in fuzzy graphs, which is an improvisation of earlier works.

**Definitions and Properties of very  $ir^f$ -excellent Graphs**

**Definition1.2.1.** Let  $G$  be a fuzzy graph and  $S$  be the set of nodes. A node  $v$  is said to be fuzzy private neighbor of  $u \in S$  with respect to  $S$ , if  $N[v] \cap S = \{u\}$ . Furthermore, we define fuzzy private neighborhood of  $u \in S$  with respect to  $S$ , to be  $pn^f[u, S] = \{v : N[v] \cap S = \{u\}\}$ . Stated in other words  $pn^f[u, S] = N[u] - N[S - \{u\}]$ . Notice that, if  $u \in pn^f[u, S]$ , then  $u$  is an isolated node in  $\langle S \rangle$ .

**Definition1.2.2.** A subset  $S$  of vertices in  $G$  is called fuzzy irredundant set if for every vertex  $v \in S$ , there exists a vertex  $w \in N[v]$  such that  $\mu(vw) \leq \sigma(v) \wedge \sigma(w)$  and  $w \in N[S - \{v\}]$ .

**Definition1.2.3.** A node  $u$  in  $S \subseteq V$  is said to be fuzzy redundant node if  $PN[u, S] = \emptyset$ . Equivalently  $u$  is redundant in  $S$  if  $N[u] \subseteq N[S - \{u\}]$ . Otherwise  $u$  is said to be fuzzy irredundant node.

**Definition1.2.4.** A fuzzy graph  $G$  is called fuzzy Irredundant excellence if every vertex of  $G$  belongs to an atleast one  $ir^f$ -set of  $G$ .

**Definition1.2.5.** A fuzzy graph  $G$  is very  $ir^f$ - excellent if  $G$  is  $isir^f$ - excellent such that for every  $u \in V - S$  there is a vertex  $v \in S$  such that  $(S - \{v\}) \cup \{u\}$  is an  $ir^f$ -set of  $G$ .

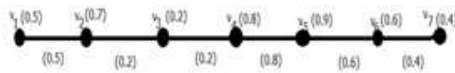


Figure 1.1

**$ir^f$ -Sets:**

- $\{v_1, v_3, v_6\}, \{v_1, v_4, v_6\}, \{v_1, v_4, v_7\}, \{v_2, v_3, v_6\},$
- $\{v_1, v_4, v_6\}, \{v_2, v_4, v_7\}, \{v_2, v_5, v_7\},$

Every vertex belongs to very  $ir^f$ -sets of  $G$ . Hence Figure 1.1 is very  $ir^f$ - excellent.

**Observation 1.2.7.** For every connected graph  $G, G \circ K_1$  is very  $ir^f$ - excellent.

**Observation 1.2.8.**  $K_{n1} \cup K_{n2} \cup \dots \cup K_{nr}$  is very  $ir^f$ - excellent.

**Observation 1.2.9.**  $ir^f(G_1 + G_2) = \min\{ir^f(G_1), ir^f(G_2)\}$

**Remark 1.2.10.** Consider the graph  $G_1 + G_2$  and let  $S$  be the subset of  $V(G_1 + G_2)$ , If  $S \cap V(G_1) \neq \emptyset$  and  $S \cap V(G_2) \neq \emptyset$  then  $S$  is not an  $ir^f$ -set.

**Remark 1.2.11.** Let  $ir^f(G_1) = ir^f(G_2)$ , and for any subset  $S$  is  $ir^f$ -set of both  $G_1$  and  $G_2$  then  $S$  is  $ir^f$ -set of  $G_1 + G_2$ .

**Remark 1.2.12.** If  $G_1$  and  $G_2$  are very  $ir^f$ - excellent then  $G_1 + G_2$  is need not be very  $ir^f$ - excellent.

**Remark 1.2.13.** For any positive integer  $k$ , then there exists a very  $ir^f$ - excellent graph with  $ir^f(G) = k$ .

**Proof.** Consider  $G = K_{n1} \cup K_{n2} \cup \dots \cup K_{nr}$  where  $n_1, n_2, \dots, n_k$  are all positive integers then  $ir^f(G) = k$  and  $G$  is very  $ir^f$ - excellent. Let us take  $n_1, n_2, \dots, n_k$  be the  $k$ -sequence of non-negative integers with  $n_i \geq 3$ . For each  $i, (1 \leq i \leq k)$ , take  $K_{ni}$  such that  $V(G_i) \cap V(G_j) = \emptyset (i \neq j)$ . For each  $j$ , select two vertices  $a_i, b_i (a_i \neq b_i)$  in  $G_i$ . Now construct a graph as follows:  $V(G) = \cup_{i=1}^k V(G_i), E(G) = \cup_{i=1}^k E(G_i) \cup \{b_k a_1 : b_i a_{i+1} / i = 1, 2, \dots, k - 1\}$  such that  $\mu(b_k a_1) \leq \sigma(b_k) \wedge \sigma(a_1)$ . Hence  $G$  is a very  $ir^f$ - excellent graph with  $ir^f(G) = k$ . □

**Remark 1.2.14.** Consider a very  $ir^f$ - excellent graph  $G$  and let  $S = \{u_1, u_2, \dots, u_k\}$  be a very  $ir^f$ -set of  $G$ . If  $v \in V - S$  then there exists a vertex  $u_i \in S$  such that  $(S - \{u_i\}) \cup \{v\}$  is an  $ir^f$ -set.

**Proposition 1.2.15.** Consider  $S = \{u_1, u_2, \dots, u_k\}$  be a  $ir^f$ - set of a simple fuzzy graph  $G$ . Let  $v \in V - S$  and  $v$  is adjacent to exactly one  $u_i \in S, (1 \leq i \leq k)$  such that  $\mu(vu_i) \leq \sigma(v) \wedge \sigma(u_i), pn^f[u_i, S] \subset N(v)$  then  $(S - \{u_i\}) \cup \{v\}$  is an  $ir^f$ - set of  $G$  provided for every  $x \in V - (S - \{u_i\}) \cup \{v\}, x$  is adjacent to some vertex of  $(S - \{u_i\}) \cup \{v\}$  such that  $\mu(xw) \leq \sigma(x) \wedge \sigma(w)$  for some  $w \in (S - \{u_i\}) \cup \{v\}$

**Proof.** Consider  $T = (S - \{u_i\}) \cup \{v\}$ , then  $v$  is an fuzzy isolate of  $G$  and hence  $v \in pn^f[v, T]$ , by hypothesis  $pn^f[u_j, T] \subset N(v)$  for any  $i \neq j$ . Therefore  $[,] \neq \emptyset$ . Thus  $T$  is an  $ir^f$ - set of  $G$ . Let us assume that  $T$  is not maximal then there exists a vertex  $x \in V - T$  such that  $(T \cup \{x\})$  is  $ir^f$ - set. Let  $S = T \cup \{x\}$ , then  $S \cup \{v\}$  is a  $ir^f$ - set which contradict that  $S$  is maximal  $ir^f$ - set of  $G$ . If  $x \neq v$ , since  $x$  is adjacent to some vertex of  $T$  such that  $\mu(x) \leq \sigma(x) \wedge \sigma(y)$ , for some  $y \in T, (y \cup \{v\}) \neq \emptyset$ . Let us take  $y \in T, (y \cup \{v\})$  which means  $y \in (S - \{u_i\}) \cup \{v\}, y$  is not adjacent to  $x$ , and any  $z \in S, z \neq v$  such that  $\mu(xz) \leq \sigma(x) \wedge \sigma(z), \mu(x) \leq \sigma(x) \wedge \sigma(v), \mu(x) > \sigma(x) \wedge \sigma(v)$





**Dharmalingam et al.,**

$(\neq)$ . Hence  $\cup \{ \}$  is an  $\gamma$ -set of  $G$  which is a contradiction. Let  $y$  is adjacent to  $x$ , and not adjacent to  $z$ ,  $x \neq z$  such that  $\mu(x) \leq \mu(y) \wedge \mu(x) > \mu(z) \wedge (x \neq z)$ , then  $\{x, y\} \subseteq \{z\}$ . Hence  $y$  is adjacent to  $z$  such that  $\mu(y) \leq \mu(x) \wedge \mu(y) > \mu(z)$  which contradicts the maximality of  $T$ ,  $|T| = |S|$ ,  $T$  is an  $\gamma$ -set of  $G$ .  $\square$

**Remark 1.2.16.** Consider  $S = \{1, 2, \dots, 3\}$  be a  $\gamma$ -set of a simple fuzzy graph  $G$  and let  $\{x\} \subseteq S$  and  $(x, y) \notin E$  for all  $y \in V - S$ , if there is  $z \in V - S$  such that  $\{x, z\} \subseteq S$  then  $(S - \{x\}) \cup \{z\}$  need not be an  $\gamma$ -set of  $G$ .

**Remark 1.2.17.** Let us consider the non-very  $\gamma$ -excellent graph and take  $S = \{1, 2, \dots, k\}$  be an  $\gamma$ -set of  $G$ . If for some  $x \in S$ , then the following conditions are satisfied

1.  $pn^f[x, S] \not\subseteq N[x]$  for any  $1 \leq j \leq k$ .
2. There is a  $u_i \in S$  such that  $N[u_i] \not\subseteq N[S - \{u_i\}]$  and  $(S - \{u_i\}) \cup \{u_i\}$  is  $ir^f$ -set but need not be maximal.

**Theorem 1.2.18.** Consider  $S = \{1, 2, \dots, k\}$  be an very  $\gamma$ -set of very  $\gamma$ -excellent graph of  $G$ . Let us take  $y \in V - S$  and for some  $u_i \in S$ ,  $N[y] \not\subseteq N[S - \{u_i\}]$  and  $pn^f[w, S] \not\subseteq N[y]$  for every  $w \in S - \{u_i\}$ . Then  $T = (S - \{u_i\}) \cup \{y\}$  is a maximal  $ir^f$ -set if and only if for every  $z \in V - (S \cup \{y\})$  holds one of the following:

- i)  $pn^f[w, S] \subseteq N[z]$  not for every  $w \in S - \{u_i\}$
- ii)  $N[y] \cap N[S - \{u_i\}] \subseteq N[z]$
- iii)  $N[z] \subseteq N[(S - \{u_i\}) \cup \{y\}]$

**Proof.** If  $z$  satisfies the one of the above conditions then  $T \cup \{z\}$  is not  $ir^f$ -set of  $G$ . Hence  $T$  is maximal. Conversely, let  $T$  is maximal then  $T \cup \{z\}$  is not an  $ir^f$ -set for every  $z \in V - (S \cup \{y\})$ . Thus, the one of the conditions hold for  $z$ .

**Illustration 1.2.19**

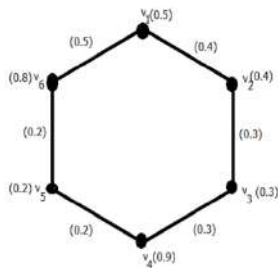


Figure 1.2

Let  $S = \{1, 2\}$  be a very  $ir^f$ -set of  $G$ .

Let us take  $u_i = 2$  and  $y = 5$ .

Hence  $T = \{1, 5\}$  be non  $\gamma^f$ -set, and consider  $z = 4 \in V - (S - \{5\})$ .

- i)  $pn^f[1, S] = N[1] - N[S - \{1\}] = \{1, 2\} \not\subseteq N[4]$
- ii)  $N[5] - N[1] = \{4, 5\} \subseteq N[4]$
- iii)  $N[4] \not\subseteq N[\{1, 2\}]$

**Definition 1.2.20.** Consider a simple fuzzy graph  $G$  and let  $u \in V(G)$ . Define

- i)  $ir^{f0}(G) = \{u \in V(G) : ir^f(G) = ir^f(G - u)\}$
- ii)  $ir^{f+}(G) = \{u \in V(G) : ir^f(G) < ir^f(G - u)\}$
- iii)  $ir^{f-}(G) = \{u \in V(G) : ir^f(G) > ir^f(G - u)\}$

If  $u \in ir^{f0}(G)$  then  $u$  is said to be  $ir^f$ -fixed in  $G$ .

**Theorem 1.2.21.** Let  $u$  be an  $ir^{f0}(G)$  vertex of very  $ir^f$ -excellent graph  $G$ . At  $u$  if we join a path of length 2 then the resulting graph  $H$  is very  $ir^f$ -excellent.

**Proof.**

Suppose the vertices of path of length  $u, v, w$  such that  $\mu(uv) \leq \sigma(u) \wedge \sigma(v)$ ,  $\mu(vw) \leq \sigma(v) \wedge \sigma(w)$  be joined at  $u$ . Then  $ir^f$ -set of  $H$  contains exactly one  $v$  or  $w$ . It is clear that the  $ir^f$ -set say  $D$  contains  $w$ . Thus  $D' = D - \{w\}$  be an  $ir^f$ -set of  $G$ . Assume that  $D'$  is not a maximal  $ir^f$ -set of  $G$ , then there is a vertex  $t \in V(G)$  such that  $D' \cup \{t\}$  is an







**Dharmalingam et al.,**

$ir^f$  –set of  $G$ . Hence  $D' \cup \{t, w\}$  be an  $ir^f$  –set of  $H$  which is a contradiction. Thus  $D'$  is a maximal  $ir^f$  –set of  $G$ .  $ir^f(G) \leq |D'| = ir^f(H) - 1$  or  $ir^f(H) \geq ir^f(G) + 1$ . Suppose  $D_1$  is an  $ir^f$  –set of  $G$ . Let us take  $D_2 = D_1 \cup \{w\}$ , then  $D_2$  is an  $ir^f$  –set of  $H$ . Hence  $ir^f(H) = ir^f(G) + 1$ . If  $S$  is a very  $ir^f$  –set of  $G$  then  $S_1 = S \cup \{w\}$  is an very  $ir^f$  –set of  $H$ . Let us take  $x \in V(H) - S_1$ , then for every  $x \in V(G)$  there is  $y \in S$  such that  $(S - \{y\}) \cup \{x\}$  is an  $ir^f$  – set of  $G$ . Hence  $(S - \{y\}) \cup \{x, w\}$  be an  $ir^f$  –set of  $H$ . Thus  $(S_1 - \{y\}) \cup \{x\}$  is  $ir^f$  –set of  $H$ .

**Case 1.** If  $u \notin S$ , then  $(S_1 - \{w\}) \cup \{v\}$  is an  $ir^f$  –set of  $H$ .

**Case 2.** Let  $u \in S$ . Assume that  $pn^f[u, S] = \emptyset$  then  $u$  is a fuzzy isolate of  $S$ .  $S \cup \{u\}$  is a maximal  $ir^f$  –set of  $G - \{u\}$ . Hence  $ir^f(G - u) \leq |S| - 1 = ir^f(G) - 1$  which is a contradiction for  $u \in ir^{f0}, ir^f(G - u) = ir^f(G)$ . Therefore  $pn^f(u, S) \neq \emptyset$  and  $(S_1 - \{w\}) \cup \{v\}$  is an  $ir^f$  –set of  $H$  and  $S_1$  is very  $ir^f$  – set of  $H$ . Therefore  $H$  is very  $ir^f$  – excellent.

**Definition 1.2.22.** If  $G$  be a very  $ir^f$  – excellent graph and let  $u \in V(G)$  is said to be very  $ir^f$  – excellent fixed then there exists a very  $ir^f$  –set  $S$  contains  $u$  such that  $w \in V - S, (S - \{v\}) \cup \{w\}$  is an  $ir^f$  – set of  $G$  for some  $v \neq u, v \in S$ .

**Theorem 1.2.23.** Consider  $G$  be a very  $ir^f$  – excellent graph and  $u$  be a very  $ir^f$  – excellent-fixed. Then  $H$  is obtained by attaching  $P_3$  at  $u$  from an edge is very  $ir^f$  – excellent with  $ir^f(H) = ir^f(G) + 1$ .

**Proof.**

Consider  $G$  be a fuzzy graph and  $u$  be a very  $ir^f$  – excellent fixed vertex. Let the path  $P_3$  (say  $w_1, w_2, w_3$ ) such that  $\mu(uw_1) \leq \sigma(u) \wedge \sigma(w_1)$  attached at  $u$ . Let  $S$  be the very  $ir^f$  –excellent set which contains  $u$ . Assume  $S_1 = S \cup \{w_2\}$  be a maximal  $ir^f$  – set. Suppose  $S_1$  is not maximal. Let  $S \cup \{y\}$  be a maximal  $ir^f$  – set of  $H$ . It is clear that  $y \neq u, w_1, w_2, w_3$  and  $y \in V(G) - \{S_1\}$ . Therefore  $S \cup \{y\}$  is fuzzy irredundant set which is a contradiction. Hence  $S_1$  is an  $ir^f$  – set of  $H$ . Hence  $ir^f(H) \leq ir^f(G) + 1$ .

Let us take  $T$  be an  $ir^f$  – set of  $H$ . Consider  $T \cap V(G) = T_1$  and if  $T = T_1$ , then  $T_1 \cup \{w_2\}$  is fuzzy irredundant in  $H$ , which is a contradiction. Hence  $T_1 \subset T$ .

**To prove:**  $T_1$  is fuzzy irredundant in  $G$ .

**Case 1:** If  $u \notin T_1$ . It is clear that  $T_1$  is fuzzy irredundant in  $G$ .

**Case 2:** Let  $u \in T_1$ .

**Subcase (i):** If  $w_1$  or  $w_2$  belong to  $T$ , then  $pn^f_G[u, T_1] \neq \emptyset$ . Hence,  $T_1$  is an  $ir^f$  – set of  $G$ . **Subcase (ii):** Let  $w_3 \in T$ . If  $pn^f_G[u, T_1] \neq \emptyset$ , then  $T_1$  is an  $ir^f$  – set of  $G$ . Assume  $pn^f_G[u, T_1] = \emptyset$ , then  $w_1$  is a fuzzy private neighbor of  $x$  with respect to  $T$ . Hence  $T_1 - \{u\}$  is an  $ir^f$  – set of  $G$ . Consider  $T_2 = T_1 - \{u\}$ .  $T_2 \cup \{w_1, w_3\}$  is an  $ir^f$  – set of  $H$  and  $|T_2 \cup \{w_1, w_3\}| = |T|$ . Hence  $T_3 = T_2 \cup \{w_1, w_3\}$  is an  $ir^f$  – set of  $H$  and  $ir^f(H) = |T| = |T_3|$ .

From above all cases either  $T_1$  or  $T_2$  is a maximal  $ir^f$  – set of  $G$ . Thus  $ir^f(G) \leq |T_1|$  or  $|T_2|$ . Hence  $ir^f(G) < ir^f(H)$  and  $ir^f(H) \geq ir^f(G) + 1$ . Therefore  $ir^f(H) = ir^f(G) + 1$ . Let us consider  $S$  be a very  $ir^f$  – excellent set of  $G$  which contains  $u$ . Then  $A = S \cup \{w_2\}$  is an  $ir^f$  – set of  $H$ . Let us take  $v \in V(G) - S$ , then there is a vertex  $x \neq u, x \in S$ , such that  $(S - \{x\}) \cup \{v\}$  is an  $ir^f$  – set of  $G$ . Then  $(S - \{x\}) \cup \{v, w_2\}$  be an  $ir^f$  – set of  $H$ . Therefore  $(A - \{w_2\}) \cup \{w_1\}$  and  $(A - \{w_2\}) \cup \{w_3\}$  are  $ir^f$  – set of  $H$ . Hence  $A$  is very  $ir^f$  – excellent set of  $H$  and  $H$  is very  $ir^f$  – excellent.

□

**Definitions of totally very  $ir^f$  – excellent and its properties**

**Definition 1.3.1.** If for every  $ir^f$  – set of  $G$  is very  $ir^f$  – set then  $G$  is called totally very  $ir^f$  – excellent.

**Remark 1.3.2.** Every graph  $G$  can be embedded in a totally very  $ir^f$  – excellent graph.

**Proof.**

We know that for every fuzzy graph  $G, ir^f(G^{f+}) = \gamma^f(G^{f+}) = |V(G)|$ . Since cardinality of every  $ir^f$  – set  $S$  of  $G^{f+}$  is less than or equal to  $n - 1$ , both  $u$  and  $u' \notin S$  for some  $u \in V(G)$ . Hence  $S \cup \{u\}$  is an  $ir^f$  – set and  $S$  is not maximal. Therefore  $ir^f(G^{f+}) = n$ . But  $ir^f(G^{f+}) \leq \gamma^f(G^{f+}) = n$ . Hence  $ir^f(G^{f+}) = n$ .  $V(G)$  is a very  $ir^f$  – set of  $G^{f+}$  and hence  $G^{f+}$  is very  $ir^f$  – excellent. Hence  $G^{f+}$  is totally very  $ir^f$  – excellent. Therefore, every fuzzy graph  $G$  can be embedded in a totally very  $ir^f$  – excellent graph.

**Observation 1.3.3.** Union of two totally very  $ir^f$  –excellent is again totally very  $ir^f$  –excellent.





**Dharmalingam et al.,**

**Lemma 1.3.4.** Let  $\phi^f$  is a fuzzy automorphism of  $G$ . If  $A$  be an  $ir^f$  – set of  $G$  then  $\phi^f(A)$  is also an  $ir^f$  – set of  $G$ .

**Proof.**

Consider  $x \in \phi^f(A)$ . Let  $x = \phi^f(u)$  for  $u \in A$ . Given that  $A$  is an  $ir^f$  – set of  $G$  then  $x \in pn^f[u, A]$ . Let us take  $w \in pn^f[u, A]$ . Assume that  $y = u$  then  $u$  is an isolate of  $A$ . Hence  $\phi^f(u)$  is an  $ir^f$  – set of  $G$ . Let us take  $w \in pn^f[u, A]$ , then  $w \in V - A$  and adjacent to only  $u \in A$  such that  $\mu(wu) \leq \sigma(w) \wedge \sigma(u)$ . Therefore  $\phi^f(w) \in V - \phi^f(A)$  and  $\phi^f(w)$  is adjacent to only  $\phi^f(u) \in \phi^f(A)$  such that  $\mu(\phi^f(u)\phi^f(w)) \leq \sigma(\phi^f(u)) \wedge \sigma(\phi^f(w))$ . Hence  $\phi^f(w) \in pn^f[\phi^f(u), \phi^f(A)]$ . Hence  $\phi^f(A)$  is an  $ir^f$  – set of  $G$ . Suppose let  $\phi^f(A)$  is not an maximal  $ir^f$  – set then there exists a vertex  $y \in V - \phi^f(A)$  such that  $\phi^f(A) \cup \{y\}$  is an  $ir^f$  – set. Hence  $z_1 \notin A$  Since if  $\phi^f(z_1) = z \in \phi^f(A)$  which is a contradiction. Hence  $\phi^f(A) \cup \{\phi^f(z_1)\}$  is  $ir^f$  – set,  $A \cup \{z_1\}$  is  $ir^f$  – set which is a contradiction. Hence  $A$  is an  $ir^f$  – set of  $G$  then  $\phi^f(A)$  is an  $ir^f$  – set of  $G$ .

**Theorem 1.3.5.** Let a fuzzy vertex transitive very  $ir^f$  – excellent graph  $G$  and  $S$  be a very  $ir^f$  – set, Such that  $S = \{u_1, u_2, \dots, u_k\}$  where  $k = ir^f(G)$ . Then there is a  $ir^f$  – set  $S'$  containing  $v \in V(G)$ .

**Proof.**

Given  $G$  is fuzzy vertex transitive then there exist a automorphism  $\phi^f$  such that  $\phi^f(u) = v$ . Let us take  $\phi^f(S) = \{\phi^f(u_1), \phi^f(u_2), \dots, \phi^f(u_k)\}$ , if  $y \in V - \phi^f(S)$  then  $\phi^{-f}(y) \notin S$ . Hence there is  $u_i \in S$  such that  $(S - \{u_i\}) \cup \phi^{-f}(y)$  is an  $ir^f$  – set of  $G$ .  $\phi^f((S - \{u_i\}) \cup \phi^{-f}(y))$  is an  $ir^f$  – set of  $G$ . Thus the set  $\phi^f(S)$  is very  $ir^f$  – excellent then  $\{v, \phi^f(u_2), \dots, \phi^f(u_k)\}$ , is very  $ir^f$  excellent. □

**Definition 1.3.6.** If very  $ir^f$  – excellent graph  $G$  contains every vertex in very  $ir^f$  – set then  $G$  is called complete very  $ir^f$  – excellent graph.

**Remark 1.3.7.** Any totally very  $ir^f$  – excellent graph  $G$  is complete very  $ir^f$  – excellent graph but converse is need not be true.

**Remark 1.3.8.** There is a totally very  $ir^f$  – excellent graph  $G$  which are not fuzzy vertex transitive. For an example  $K_4^{f+}$  which is very  $ir^f$  – excellent graph but it is not fuzzy vertex transitive graph.

**Lemma 1.3.9.** If a fuzzy caterpillar  $T$  with spine  $\{u_1, u_2, \dots, u_k\}$  is  $ir^f$  – excellent then the number of fuzzy pendant vertices at  $u_i$ ,  $(1 \leq i \leq k)$  is either 0 or 1.

**Proof.**

Let us assume that there is  $i$ ,  $(1 \leq i \leq k)$  such that  $u_i$  has two or more fuzzy pendant vertices. Consider two fuzzy pendant vertices  $w_1$  and  $w_2$  such that  $\mu(u_i w_1) \leq \sigma(u_i) \wedge \sigma(w_1)$ ,  $\mu(u_i w_2) \leq \sigma(u_i) \wedge \sigma(w_2)$  and  $\sigma(w_1) = 1, \sigma(w_2) = 1$ . Since  $T$  is  $ir^f$  – excellent then there exists a  $ir^f$  – set  $S$  of  $T$  contains  $w_1$ . Thus  $S_1 = S \cup \{w_2\}$  is a  $ir^f$  – set which is a contradiction to maximality of  $S$ . Hence the lemma. □

**Lemma 1.3.10.** If a fuzzy caterpillar  $T$  with spine  $\{u_1, u_2, \dots, u_k\}$  is  $ir^f$  – excellent then the number of fuzzy pendant vertices at  $u_1$  and  $u_k$  is 1.

**Proof.**

If  $u_1$  and  $u_k$  has no fuzzy pendant vertices then  $u_1$  and  $u_k$  cannot be in the spine of fuzzy caterpillar  $T$  which is a contradiction. □

**Lemma 1.3.11.**

Let  $A$  be the subset of the spine of fuzzy caterpillar  $T$  which is  $ir^f$  – set. If  $A$  doesn't contain some  $u_i$  then  $A$  is not minimal.

**Proof.**

If  $u_i \notin A$  and  $w_i$  be a fuzzy pendant at  $u_i$  such that  $\mu(u_i w_i) \leq \sigma(u_i) \wedge \sigma(w_i)$  then  $A \cup \{w_i\}$  is  $ir^f$  – set which is a contradiction to maximality of  $A$ . □

**Remark 1.3.12.** Let  $A$  is a maximal set of  $T$  and  $A$  is a subset of the spine of  $T$ , then  $A$  contains all the support of spine of  $T$ .

**Corollary 1.3.13.** Let  $A$  is an  $ir^f$  – set of  $T$  and it is contained in spine of  $T$ , and if all the supports on the spine contained in  $A$  and if distance between two consecutive supports less than or equal to 3, then  $A$  is maximal  $ir^f$  – set.

**Proof**





**Dharmalingam et al.,**

Consider the consecutive supports  $u_i, u_j$  in  $A$  and  $d^f(u_i, u_j) \leq 3$ . Let us take  $u_i, u_{i_1}, u_{i_2}, u_j$  are the consecutive vertices on the spine  $T$  such that  $\mu(u_i u_{i_1}) \leq \sigma(u_i) \wedge \sigma(u_{i_1}), \mu(u_{i_1}, u_{i_2}) \leq \sigma(u_{i_1}) \wedge \sigma(u_{i_2}), \mu(u_{i_2}, u_j) \leq \sigma(u_{i_2}) \wedge \sigma(u_j)$  with  $u_{i_1}, u_{i_2}$  are non-supports, then  $A \cup \{u_{i_1}\}$  and  $A \cup \{u_{i_2}\}$  are non  $ir^f$  -set, Hence  $A$  is maximal.

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## A Scoping Review to Determine the Efficacy of Kinesiotape Impact in the Prevention and Symptomatic Relief of Delayed Onset Muscle Soreness

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### ABSTRACT

The effectiveness of Kinesio Tape (KT) in preventing and treating Delayed Onset Muscle Soreness (DOMS) is examined in this review of the research. Muscle pain brought on by DOMS, which results from eccentric exercise, peaks within 24 to 48 hours. By lifting the skin lowering pressure and enhancing blood flow, KT application may help to lessen the symptoms of DOMS. To Analyze the literature on the efficacy of Kinesiotape impact in the prevention and symptomatic relief of Delayed Onset Muscle soreness. The analysis of ten articles from 2012 to 2021 revealed KT's beneficial effects on pain, muscle strength, and range of motion. According to the findings, persistent KT application significantly lessens discomfort compared to controls. Application of KT after 48 hours improves muscle strength and pain alleviation. Overall, Kinesio Taping appears to be a successful method for reducing the symptoms of DOMS, but bigger randomized trials are required for definitive proof and wider clinical implications. This article suggests that KT is quite effective in decreasing pain, and muscle soreness, and improving ROM and muscle strength

**Keywords:** Kinesio, Muscle, symptoms, pain.

### INTRODUCTION

Delayed Onset Muscle Soreness (DOMS) is a muscle soreness and discomfort after eccentric exercise that occurs within 24 hours peaks up to 24 to 48 hours and commonly resolves within 5 to 7 days. It is associated with increased physical exertion. DOMS is experienced by all individuals regardless of fitness level, and the introduction to

70587



**Arnold Nikhilesh et al.,**

unfamiliar physical activities. It occurs due to muscle overloading in a large amount of eccentric contraction. When the load exceeds the capacity of the muscle, active tension occurs and the muscle stretches lead to muscle damage. The symptoms include Pain, muscle tenderness, stiffness, swelling, and loss of muscle strength. Kinesiotaping (KT) is a therapeutic method that aims to restore body functions using the sensory-motor system communication rule. When KT is applied it will lift up the surface of the skin and form a wide space between the skin and the muscle that reduces the pressure, and stimulates receptors and nerve endings, in turn, it will increase the blood flow of the damaged muscle tissue and reduce swelling. The KT was applied to avoid cramps or contractures, relax, and diminish the muscular tone. It can be useful for improvement of the blood circulation and the decrease of perceived pain.

**MATERIALS AND METHODS****Inclusion Criteria**

Clinical studies that met the following criteria were included: randomized controlled trials (RCTs) in humans with a major aim of evaluating the effectiveness of KT for DOMS. KT as the intervention; Control individuals who received no treatment, or placebo tape treatment or rest; Outcome measures were muscle soreness and muscle strength.

**Exclusion Criteria**

Clinical studies were excluded if there were only an abstract, reported no mean value or standard deviation, and interventions other than KT for DOMS.

**Selection of sources of evidence**

We collected the articles from four databases- Google Scholar, Pubmed, Research Gate, and Pedro and got 10 articles from the year 2012 to 2021 that state the prevention and treatment of DOMS. The studies conducted on reducing and preventing DOMS by using Kinesiotape were included. The studies conducted with the intervention other than KT for DOMS were excluded. The articles were collected using the following keywords: Kinesio Tape, Delayed Onset Muscle Soreness, Eccentric Exercise, and Muscle Damage.

**Participants**

To be part of this study, the available articles are needed to focus on the DOMS and their damage and the effect of the Kinesio-Taping on the DOMS.

**Context**

This review was intended to determine whether the application of kinesio-tape will reduce the impact of the DOMS-affected population.

**Search Strategy**

The specific search strategy used was as follows: DOMS, Kinesio-Taping, Randomised control trials, and effectiveness. Following the completion of the search, the references in the papers were selected and also reviewed to include. Additional articles that were not found in the original electronic search

**Focused question**

The scoping review question mainly focused on the following: What is the available evidence in the form of RCTs showing the effectiveness of DOMS? and What is the available evidence in the form of RCT showing the effectiveness of Kinesio-Taping on DOMS?

**Data Extraction**

Following the preliminary screening of collected articles and the identification of key factors within the studies, the subsequent phase involves a comprehensive examination of each article to extract additional data necessary for





**Arnold Nikhilesh et al.,**

generating the results. We found out that there is an effect on applying Kinesio-tape For the gym-going beginners to reduce the DOMS. This will give the symptomatic relief to the person.

**Data items**

Data were independently obtained from available eligible RCTs by one author. The characteristics chosen weretitle, author and year of publication, number of samples, study duration, Kinesiotape application, Effectiveness of DOMS, and Scales used to measure the severity.

**REVIEW OF LITERATURE**

- Kim J. and colleagues [1] conducted a study to explore whether prolonged application of KT affects muscle damage markers following eccentric exercise. The study involved 32 male participants who were randomly assigned to four groups: control, KT-post, KT-30min, and KT-24hr. The KT-24hr group exhibited reduced muscle damage and quicker recovery compared to the Control and KT-post groups. Both the KT-30min and KT-24hr groups experienced less soreness than the control and KT-post groups. These findings indicated that extended KT application had a positive impact on muscle damage markers.
- Kruszyniewicz J. et al. [2] undertook a study to investigate KT's potential analgesic effect on delayed onset muscle soreness (DOMS) and whether somatotype played a role. The study included 20 healthy individuals with moderate or high physical activity. Significant reduction in DOMS intensity was observed in the limb where KT was applied, compared to the untreated limb. The study concluded that KT does possess analgesic properties in DOMS, and somatotype doesn't influence its effectiveness.
- Jianping Lin et al. [3] conducted a systematic review and meta-analysis to assess KT's efficacy in alleviating DOMS. The study analyzed various trials up to December 31, 2019. KT usage was found to significantly decrease muscle soreness at 48 h and 72 h post-exercise, and improve muscle strength at 72 h post-exercise. However, no significant difference in serum creatine kinase levels was observed. The study suggested that using KT on the skin for over 48 hours post-exercise could effectively reduce pain and enhance muscle strength.
- Boobpachat D. et al. [4] conducted a randomized controlled trial to examine KT's effect on reducing delayed onset muscle soreness (DOMS). Participants were divided into Kinesio tape (KT), Placebo tape (PT), and Stretching groups (SG). The study found that KT increased muscle strength recovery after intensive exercise compared to placebo tape and reduced perceived muscle soreness compared to stretching.
- Yong Sin Lee et al. [5] investigated the effects of KT on muscle function and pain in individuals with DOMS. Activation of muscles through KT application was shown to be an effective and faster method of recovering muscle strength compared to rest alone.
- Rezaei M. et al. [6] conducted a clinical trial with 32 untrained individuals to assess KT's efficacy in reducing pain and improving function during delayed onset muscle soreness. The study concluded that KT could significantly reduce pain intensity at 24 hrs and 48 hrs post-intervention, but showed no significant advantage in other DOMS-induced parameters like pressure pain threshold.
- Bao-Lien Hung et al. [7] conducted a randomized controlled trial to investigate different KT applications for DOMS after High-Intensity Interval Training. The study found that crisscross weave KT application on quadriceps muscles improved muscle strength recovery after HIIT, while Y-Y-shaped KT application did not.
- Kirmizigil B. et al. [8] investigated the impact of rectus femoris KT application on enhancing recovery from delayed onset muscle soreness. KT demonstrated favorable effects on reducing muscle soreness and improving horizontal jump performance and dynamic balance.
- Sea-Hyun Bae et al. [9] studied the pain reduction effects of Kinesio taping on artificially induced delayed onset muscle soreness. Kinesio taping was found to significantly decrease pain 72 hours after DOMS induction relative to 24 hours.
- Merino R. et al. [10] evaluated the use of Kinesio tape for pain perception after triathlon competitions. Application of Kinesio tape before warm-up was associated with minimal perceived pain and soreness in the gastrocnemius and



**Arnold Nikhilesh et al.,**

soleus muscles post-race. This suggests the potential for Kinesio tape to prevent injuries and cramps during competition for triathletes and duathletes.

## RESULT

From the collected articles, 334 participants underwent KT application. The studies included in this study showed that KT has an effect on Pain, range of motion, and muscle strength and also exhibits an analgesic effect on DOMS. The KT -30min and KT-24 hr groups showed lesser Soreness than the control and KT-post groups. These findings suggested that prolonged application of KT positively affected markers of muscle damage<sup>[1]</sup>. In the limb where KT application was used a significant ( $p < 0.05$ ) reduction in the intensity of DOMS compared to the limb without application was observed<sup>[2]</sup>. Using KT on the skin for more than 48 hours postexercise, but not for 24 hours, appears more effective at relieving pain and improving muscle strength<sup>[3]</sup>. The application of KT increased muscle strength recovery after intensive exercise compared to placebo tape and reduced perceived muscle soreness compared to stretching<sup>[4]</sup>. Thus, the current study results that kinesiotaping reduces DOMS-induced parameters like- pain, and muscle soreness and also improves Range of motion and function. The evidence supports the use of Kinesiotaping in DOMS since the studies included in this review are beneficial.

## CONCLUSION

The findings of this review indicate that Kinesiotaping is efficacious in reducing and preventing Delayed Onset Muscle Soreness. It is suggested that KT is quite effective in decreasing pain, and muscle soreness, and improving ROM and muscle strength. The Guidelines given in this review will help to achieve higher-quality results and also determine the effectiveness of KT in reducing and preventing DOMS. Since the articles about KT application on DOMS are inadequate in quantities, additionally, large-sized, randomized, blinded trials are needed to clarify the actual role of KT in patients with DOMS. Furthermore, research is to be conducted to find the efficacy of KT application for acute muscle soreness or DOMS. Hence, this research will be beneficial for clinicians and practitioners to make clinical decisions and also to upgrade the treatment.

### Conflict of interest

The authors state no conflict of interest.

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### Disclosure statement

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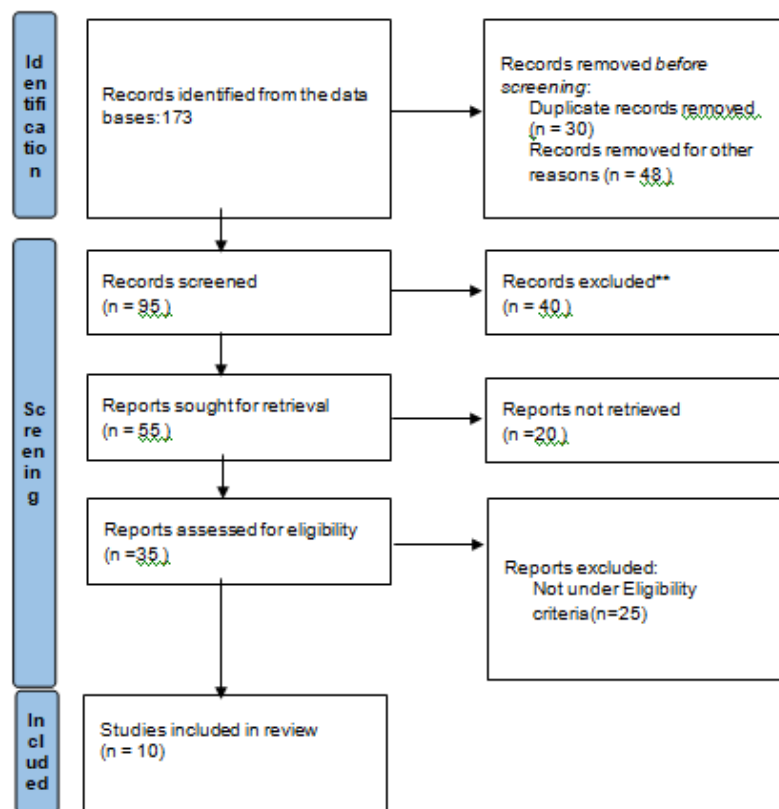
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## Impact of Circuit Training with Different Frequencies and Durations on Mean Arterial Pressure of School Students

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### ABSTRACT

The purpose of the present investigation is to examine the impact of circuit training with different frequencies and durations on mean arterial pressure of school students. To achieve the purpose of this study, sixty school boys from various schools at Sivakasi, Tamil Nadu, India, were selected as subjects. The age, height and weight of the subjects ranged from 15 to 17 years, 150 to 160 centimeters and 40 to 50 kilograms respectively. They were divided into four groups; each group consisted of fifteen students. CT-Group-I were undergone thirty minutes circuit training three days in a week, CT-Group-II were undergone thirty minutes circuit training five days in a week, CT-Group-III were undergone forty five minutes circuit training three days in a week and CT-Group-IV were undergone forty five minutes circuit training five days in a week. The data collected from the four groups prior to and post experimentation on selected dependent variables were statistically analyzed to find out the significant difference if any, by applying the analysis of covariance (ANCOVA). Since four groups were involved, whenever the obtained 'F' ratio for adjusted post test means was found to be significant, the Scheffe's test was applied as post hoc test to determine the paired mean differences. In all the cases level of confidence was fixed at 0.05 for significance. Result showed that the school student's mean arterial pressure level significantly decreased due to different frequencies and durations of circuit training from the base level of the student's performance. And also among the four groups, the CT-Group-IV student's mean arterial pressure level was significantly decreased comparing to other groups.

**Keywords:** Circuit Training and Mean Arterial Pressure.



**John and Madhanagopal****INTRODUCTION**

Physical fitness refers to the capacity of an athlete to meet the varied physical demands of their sport without reducing the athlete to a fatigued state. Physical fitness and mental stability go one in one, as research suggests that although physical and aerobic activity wells ones physical potentials, it also helps with ones positive body icon and self esteem. Studies show that physical fitness helps develop positive body icon and self esteem, perceivable increased stress management, reduction of depression and anxiety (McClernon, et al., 2007) as well as increase mood states and develop overall cognitive function. Circuit training is a form of body conditioning that occupies endurance training, resistance training, high-intensity aerobics, and exercises executed in a circuit, similar to high-intensity interval training. It targets strength building and muscular endurance. An exercise "circuit" is one completion of all set exercises in the program. When one circuit is completed, one begins the first exercise again for the next circuit. Conventionally, the time between exercises in circuit training is short and often with quick movement to the next exercise (Comyns, 2018). Circuit training in itself is not a form of exercise per set, but the way an exercise session is structured (Scholich, 1992). A circuit session consists of a series of exercises or stations performed in succession with minimal rest intervals in between. Routines can be developed purely for strength development or for enhancing endurance or some combination of the two.

**METHODOLOGY**

The purpose of the present investigation is to examine the impact of circuit training with different frequencies and durations on mean arterial pressure of school students. To achieve the purpose of this study, sixty school boys from various schools at Sivakasi, Tamil Nadu, India, were selected as subjects. The age, height and weight of the subjects ranged from 15 to 17 years, 150 to 160 centimeters and 40 to 50 kilograms respectively. They were divided into four groups; each group consisted of fifteen students. CT-Group-I were undergone thirty minutes circuit training three days in a week, CT-Group-II were undergone thirty minutes circuit training five days in a week, CT-Group-III were undergone forty five minutes circuit training three days in a week and CT-Group-IV were undergone forty five minutes circuit training five days in a week. The mean arterial pressure was measured by digital blood pressure monitor. The data collected from the four groups prior to and post experimentation on mean arterial pressure were statistically analyzed to find out the significant difference if any, by applying the analysis of covariance (ANCOVA). Since four groups were involved, whenever the obtained 'F' ratio for adjusted post test means was found to be significant, the Scheffe's test was applied as post hoc test to determine the paired mean differences. In all the cases level of confidence was fixed at 0.05 for significance.

**TRAINING PROGRAMME**

In this study, training was done under close supervision with frequent adjustments in training intensity to maintain the desired training stimulus. The training programmes were scheduled for one session a day for all the four circuit training groups. Group-I underwent 30 minutes circuit training for three days for twelve weeks, this training was executed in the 400m track the intensity of the training increased progressively across the weeks. Intensity based on the no of sets (2 to 4) and repetitions (4 to 7) with 8 exercises. Group-II underwent 30 minutes circuit training for five days for twelve weeks, this training was executed in the 400m track the intensity of the training increased progressively across the weeks. Intensity based on the no of sets (2 to 4) and repetitions (4 to 7) with 8 exercises. Group-III underwent 30 minutes circuit training for three days for twelve weeks, this training was executed in the 400m track the intensity of the training increased progressively across the weeks. Intensity based on the no of sets (2 to 4) and repetitions (4 to 7) with 10 exercises.

Group-IV underwent 30 minutes circuit training for five days for twelve weeks, this training was executed in the 400m track the intensity of the training increased progressively across the weeks. Intensity based on the no of sets (2 to 4) and repetitions (4 to 7) with 10 exercises.







## STATISTICAL TECHNIQUE

The data collected from the four groups prior to and post experimentation were statistically analyzed to find out the significant difference if any, by applying the analysis of covariance (ANCOVA). In all the cases statistical significance was fixed at 0.05 levels.

## RESULTS

### Analysis of Covariance of Different Frequencies of Circuit Training on Mean Arterial Pressure

(The required table value for significance at 0.05 level of confidence with degrees of freedom 3 and 55 is 2.77 and degree of freedom 3 and 56 is 2.77) \*Significant at .05 level of confidence. The CT-Group-I, CT-Group-II, CT-Group-III, and CT-Group-IV pre test mean values are 94.13, 93.33, 93.46 and 92.73 respectively on mean arterial pressure. The brought out "F" value is 0.70 which is lower than the required table value of 2.77 (df3&56=2.77). It revealed that there were no significant differences among the various frequencies of circuit training (CT) groups on mean arterial pressure. The CT-Group-I, CT-Group-II, CT-Group-III, and CT-Group-IV post test mean values are 92.13, 89.33, 90.66 and 87.53 respectively on mean arterial pressure. The brought out "F" value is 7.88 which is higher than the required table value of 2.77 (df3&56=2.77). It revealed that there were significant differences among the various frequencies of circuit training (CT) groups on mean arterial pressure. The adjusted post test mean value attained through ANCOVA statistics on mean arterial pressure of the four different frequencies of circuit training (CT) groups are 91.41, 89.41, 90.61 and 88.22 respectively, since adjusted 'F' ratio value 25.73 on mean arterial pressure of four circuit training groups is significant (df3&55=2.77). It is decisive that due to different frequencies of circuit training (12 weeks) the school students on mean arterial pressure performance is remarkably raised from the base level. Since, the adjusted post test 'F' ratio value is found to be significant the Scheffe's test was applied as post hoc test to decide the paired mean differences, and it is presented in table-2. The mean differences (MD) of CT-Group-I and CT-Group-II (2.00), CT-Group-I and CT-Group-III (3.19), CT-Group-I and CT-Group-IV (1.20), CT-Group-II and CT-Group-IV (1.19), CT-Group-III and CT-Group-IV (2.39), are higher than confidence interval [CL=1.10, (0.05 level) value on mean arterial pressure. It shows the significant difference among the above groups on decreasing their mean arterial pressure. Moreover mean differences (MD) of CT-Group-II and CT-Group-III (0.80), is lower than confidence interval [CL=1.10, (0.05 level) value on mean arterial pressure. The school student mean arterial pressure level significantly decreased due to different frequencies of circuit training from the base level of the student's performance. And also among the four groups, the CT-Group-IV students mean arterial pressure level was significantly reduced comparing to other groups.

## DISCUSSION

The decisive stated that due to different frequencies of circuit training (12 weeks) the school students on mean arterial pressure level is remarkably decreased from the base level. And also among the four groups, the CT-Group-IV students mean arterial pressure level was significantly decreased comparing to other groups. The subsequent studies are confined with our study results. Verena, et al., (2021) investigated the effects of regular long-term circuit training (once per week) on cardio respiratory fitness (CRF) in sedentary adults and (2) to compare training progress with the effects of continued exercise participation by regularly active age-matched individuals. It reduced systolic BP during sub maximal exercise, indicating improved exercise tolerance. Diogo, et al., (2020) conducted effect of circuit training on resting blood pressure: an experimental study in hypertensive older women. The CT protocol is efficient for improving physical conditioning and reducing systolic blood pressure in hypertensive older women. Muthuraj (2017) conducted impact of concurrent strength and endurance training on mean arterial pressure. The result of the study pointed out that concurrent strength and endurance training groups decreased on mean arterial pressure due to the twelve weeks of concurrent training programme. Vrachimis, et al., (2016) examined the effect of circuit training (CT) on resting heart rate variability (HRV) and other cardiovascular disease (CVD) risk factors such as blood lipids and blood glucose and on fitness components. This training might decrease the risk for development of CVD by



**John and Madhanagopal**

reducing arterial blood pressure and by improving body composition, aerobic capacity, muscular endurance and strength. Allyson, et al., (2018) study examined the effects of a 4-week exercise circuit training (CT) intervention on vascular health and fitness in volunteer. They found that brachial and central BP decreased with circuit training exercise. Paoli, et al., (2013) determined the physiological effects of a high-intensity circuit training (HICT) on several cardiovascular disease risk factors in healthy, overweight middle-aged subjects. The findings indicate that high-intensity circuit training is more effective in improving blood pressure, lipoproteins and triglycerides than endurance training alone or lower intensity circuit training.

**CONCLUSION**

The conclusion of the study pointed out that the school student mean arterial pressure level significantly decreased due to different frequencies and durations of circuit training from the base level of the student's performance. And also among the four groups, the CT-Group-IV students mean arterial pressure level was significantly decreased comparing to other experimental groups.

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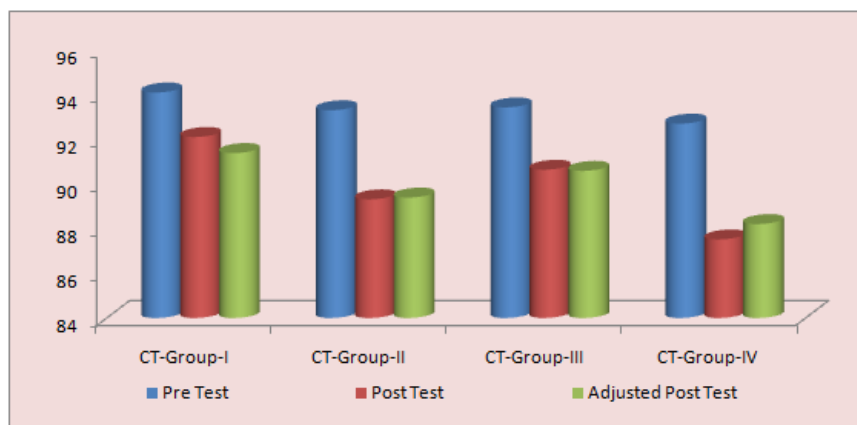
**John and Madhanagopal**

**Table-1 . Analysis of Covariance of Different Frequencies of Circuit Training on Mean Arterial Pressure**

	CT-Group-I	CT-Group-II	CT-Group-III	CT-Group-IV	S O V	Sum of Squares	df	Mean squares	'F' ratio
Pre test Mean	94.13	93.33	93.46	92.73	B	14.85	3	4.95	0.70
SD	2.85	2.66	2.53	2.54	W	393.73	56	7.03	
Post test Mean	92.13	89.33	90.66	87.53	B	172.45	3	57.48	7.88*
SD	2.85	2.66	2.84	2.41	W	408.13	56	7.28	
Adjusted Post test Mean	91.41	89.41	90.61	88.22	B	84.94	3	28.31	25.73*
					W	60.79	55	1.10	

**Table-2 Scheffe's Test - Different Frequencies of Circuit Training on Mean Arterial Pressure**

Adjusted Post Test Means				DM	CI
CT-Group-I	CT-Group-II	CT-Group-III	CT-Group-IV		
91.41	89.41			2.00*	1.10
91.41		90.61		0.80	1.10
91.41			88.22	3.19*	1.10
	89.41	90.61		1.20*	1.10
	89.41		88.22	1.19*	1.10
		90.61	88.22	2.39*	1.10



**Figure -I. Diagram Showing that the Mean Value of Different Frequencies of Circuit Training on Mean Arterial Pressure**





## On New Class of Continuous Functions in Topological Spaces

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### ABSTRACT

The aim of this paper is to introduce a new class of continuous function called  $\hat{g}\pi$  - continuous function by using  $\hat{g}\pi$ -closed set in topological spaces and discussed their basic properties.

**Keywords:**  $\hat{g}\pi$  -closed set,  $\hat{g}\pi$  - open set,  $\hat{g}\pi$  -continuous .

## INTRODUCTION

In the year 1970, Norman Levine initiated the idea of continuous functions. Noiri (1980) introduced  $\pi$ -continuity. Munshi (1982) defined super continuous functions. The generalized continuity concept was studied by Balachandran (1991). Further many authors contributed their research towards continuity. In this paper, we introduce a new class of function called  $\hat{g}\pi$  - continuous function and study some of their properties.

### Preliminaries

Throughout this paper,  $X, Y$  and  $Z$  denote the topological spaces  $(X, \tau), (Y, \sigma)$  and  $(Z, \gamma)$  respectively and have no separation axioms are assumed. For a subset  $A$  of a space  $X$ ,  $cl(A)$  and  $int(A)$  denote the closure of  $A$  and the interior of  $A$  respectively.

Definition 2.1. A subset  $A$  of a topological space  $X$  is called

(i) a pre-open set [13] if  $A \subseteq int(cl(A))$ .

(ii) a semi-open set [7] if  $A \subseteq cl(int(A))$ .

(iii) a semi-pre open set [1] if  $A \subseteq cl(int(cl(A)))$ .





### Vijayalakshmi and Thiripurasundari

(iv) a regular-open set [15] if  $A = \text{int}(cl(A))$ .

Definition 2.2. [18] For any subset  $A$  of  $(X, \tau)$ ,  $\pi cl(A) = \cap \{B : B \supseteq A, B \text{ is a } \pi\text{-closed subset of } X\}$ .

Definition 2.3. A subset  $A$  of a topological space  $X$  is called

(i)  $g$ -closed [8] if  $cl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is open in  $X$ .

(ii)  $gs$ -closed [2] if  $scl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is open in  $X$ .

(iii)  $g\alpha$ -closed [10] if  $acl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is  $\alpha$ -open in  $X$ .

(iv)  $\alpha g$ -closed [9] if  $scl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is open in  $X$ .

(v)  $gsp$ -closed [6] if  $spcl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is open in  $X$ .

(vi)  $gp$ -closed [9] if  $pcl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is open in  $X$ .

(vii)  $g^*$ -closed [12] if  $cl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is  $g$ -open in  $X$ .

(viii)  $\pi g$ -closed [19] if  $cl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is open in  $X$ .

(ix)  $\pi gs$ -closed [19] if  $scl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is  $\pi$ -open in  $X$ .

(x)  $\pi gr$ -closed [19] if  $rcl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is  $\pi$  open in  $X$ .

(xiii)  $\pi gb$ -closed [19] if  $bcl(A) \subseteq U$  whenever  $A \subseteq U$  and  $U$  is  $\pi$  open in  $X$ .

Definition 2.4. A function  $f : X \rightarrow Y$  is called

(i) Continuous [7] if  $f^{-1}(V)$  is closed in  $X$  for every closed subset  $V$  of  $Y$ .

(ii) Regular Continuous [7] if  $f^{-1}(V)$  is regular closed in  $X$  for every closed subset  $V$  of  $Y$ .

(iii)  $g$ -Continuous [8] if  $f^{-1}(V)$  is  $g$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

(iv)  $gr$ -Continuous [10] if  $f^{-1}(V)$  is  $gr$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

(v)  $gsp$ -Continuous [14] if  $f^{-1}(V)$  is  $gsp$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

(vi)  $gp$ -Continuous [14] if  $f^{-1}(V)$  is  $gp$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

(vii)  $\alpha g$ -Continuous [9] if  $f^{-1}(V)$  is  $\alpha g$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

(viii)  $\pi g$ -Continuous [19] if  $f^{-1}(V)$  is  $\pi g$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

(ix)  $\pi gr$ -Continuous [19] if  $f^{-1}(V)$  is  $\pi gr$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

(x)  $g^*\pi$ -continuous [11] if  $f^{-1}(V)$  is  $g^*\pi$ -closed in  $X$  for every closed subset  $V$  of  $Y$ .

#### $\hat{g}\pi$ -Continuous functions

**Definition 3.1.** A function  $f : X \rightarrow Y$  is said to be  $\hat{g}\pi$ -continuous if the inverse image of every closed set in  $Y$  is  $\hat{g}\pi$ -closed in  $X$ .

**Theorem 3.2.** A function  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous if  $f$  is continuous.

**Proof.** Let  $U$  be an open set in  $Y$ . since  $f$  is continuous,  $f^{-1}(U)$  is open in  $X$  which implies  $f$  is  $\hat{g}\pi$ -continuous.

**Theorem 3.3.** Every  $\pi$ -continuous function is  $\hat{g}\pi$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\pi$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\pi$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$ . Hence  $f$  is  $\hat{g}\pi$ -continuous.

**Example 3.4.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \emptyset, \{a_1\}, \{a_1, b_1\}, \{a_1, c_1\}\}$  and  $\sigma = \{Y, \emptyset, \{a_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be the identity function. Clearly  $f$  is  $\hat{g}\pi$ -continuous, but not  $\pi$ -continuous because  $f^{-1}(\{b_1, c_1\}) = \{b_1, c_1\}$  is not  $\pi$ -closed in  $X$  where  $\{b_1, c_1\}$  is closed in  $Y$ .

**Theorem 3.5.** Every  $\hat{g}\pi$ -continuous is  $\pi g$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous and let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  which implies  $\pi g$ -closed in  $X$ . Hence  $f$  is  $\pi g$ -continuous.







### Vijayalakshmi and Thiripurasundari

**Example 3.6.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}, \{a_1, c_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be the identity function. Clearly  $f$  is  $\pi g$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1\}) = \{a_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1\}$  is closed in  $Y$ .

**Theorem 3.7.** Every  $\hat{g}\pi$ -continuous is  $g$ -semi continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $g\pi b$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$ . Hence  $f$  is  $g$ -semi continuous.

**Example 3.8.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, c_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be the identity function. Clearly  $f$  is  $g$ -semi continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{b_1\}) = \{b_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{b_1\}$  is closed in  $Y$ .

**Theorem 3.9.** Every  $\hat{g}\pi$ -continuous is  $\pi gb$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous and let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  which implies  $\pi gb$ -closed in  $X$ . Hence  $f$  is  $\pi gb$ -continuous.

**Example 3.10.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}, \{a_1, c_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be the identity function. Clearly  $f$  is  $\pi gb$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1\}) = \{a_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1\}$  is closed in  $Y$ .

**Theorem 3.11.** Every  $\hat{g}\pi$ -continuous is  $\pi gr$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous and let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $g\pi b$ -closed in  $X$  which implies  $\pi gr$ -closed in  $X$ . Hence  $f$  is  $\pi gr$ -continuous.

**Example 3.12.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be the identity function. Clearly  $f$  is  $\pi gr$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1\}) = \{a_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1\}$  is closed in  $Y$ .

**Theorem 3.13.** Every  $\hat{g}\pi$ -continuous is  $\pi gr$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous and let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $g\pi b$ -closed in  $X$  which implies  $\pi gr$ -closed in  $X$ . Hence  $f$  is  $\pi gr$ -continuous.

**Example 3.14.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be the identity function. Clearly  $f$  is  $\pi gr$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1\}) = \{a_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1\}$  is closed in  $Y$ .

**Theorem 3.14.** Every  $\hat{g}\pi$ -continuous is  $\pi gr$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $g\pi b$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $g$ -closed in  $X$ . Hence  $f$  is  $g$ -continuous.

**Example 3.15.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{c_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{c_1\}, \{a_1, c_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  by be the identity function. Clearly  $f$  is  $g$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1\}) = \{a_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1\}$  is closed in  $Y$ .

**Theorem 3.16.** Every  $\hat{g}\pi$ -continuous is  $rg$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $rg$ -closed in  $X$ . Hence  $f$  is  $rg$ -continuous.

**Example 3.17.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{c_1\}, \{a_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be the identity function. Clearly  $f$  is  $rg$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1, b_1\}) = \{a_1, b_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1, b_1\}$  is closed in  $Y$ .

**Theorem 3.18.** Every  $\hat{g}\pi$ -continuous is  $gb$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $gb$ -closed in  $X$ . Hence  $f$  is  $gb$ -continuous.

**Example 3.19.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{c_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{c_1\}, \{a_1, c_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  by be the identity function. Clearly  $f$  is  $gb$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{b_1\}) = \{b_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{b_1\}$  is closed in  $Y$ .

**Theorem 3.20.** Every  $\hat{g}\pi$ -continuous is  $gp$ -continuous but not conversely.

**Proof.** Let  $f : X \rightarrow Y$  is  $g\pi b$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $gp$ -closed in  $X$ . Hence  $f$  is  $gp$ -continuous.

**Example 3.21.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{b_1\}, \{a_1, b_1\}\}$ . Let  $f : X \rightarrow Y$  by be the identity function. Clearly  $f$  is  $gp$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{c_1\}) = \{c_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{c_1\}$  is closed in  $Y$ .





**Vijayalakshmi and Thiripurasundari**

**Theorem 3.22.** Every  $\hat{g}\pi$ -continuous is  $g\alpha$ -continuous but not conversely.

Proof. Let  $f : X \rightarrow Y$  is  $g\pi b$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $g\alpha$ -closed in  $X$ . Hence  $f$  is  $g\alpha$ -continuous.

**Example 3.23.** Let  $X = Y = \{a_1, b_1, c_1\}, \tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  by be the identity function. Clearly  $f$  is  $g\alpha$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1\}) = \{a_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1\}$  is closed in  $Y$ .

**Theorem 3.24.** Every  $\hat{g}\pi$ -continuous is  $\alpha g$ -continuous but not conversely.

Proof. Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $\alpha g$ -closed in  $X$ . Hence  $f$  is  $\alpha g$ -continuous.

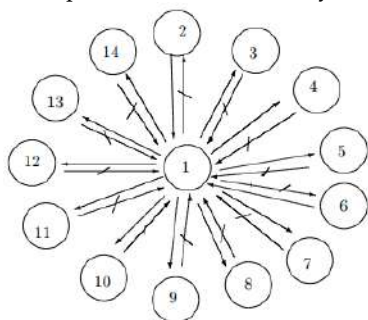
**Example 3.25.** Let  $X = Y = \{a_1, b_1, c_1\}, \tau = \{X, \varphi, \{b_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{b_1\}, \{b_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  by be the identity function. Clearly  $f$  is  $g$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{a_1\}) = \{a_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{a_1\}$  is closed in  $Y$ .

**Theorem 3.26.** Every  $\hat{g}\pi$ -continuous is  $g^*\pi$ -continuous.

Proof. Let  $f : X \rightarrow Y$  is  $\hat{g}\pi$ -continuous. let  $V$  be closed in  $Y$ . Then  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  and therefore  $f^{-1}(V)$  is  $g^*\pi$ -closed in  $X$ . Hence  $f$  is  $g^*\pi$ -continuous.

**Example 3.27.** Let  $X = Y = \{a_1, b_1, c_1\}, \tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}, \{a_1, c_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  by be the identity function. Clearly  $f$  is  $\pi g$ -continuous, but not  $\hat{g}\pi$ -continuous because  $f^{-1}(\{b_1\}) = \{b_1\}$  is not  $\hat{g}\pi$ -closed in  $X$  where  $\{b_1\}$  is closed in  $Y$ .

**Remark 3.28.** The above discussions are summarized in the following diagrammatic representation.  $A \rightarrow B$  represents A implies B but not conversely.



1.  $\hat{g}\pi$ -continuous
2.  $\pi$ -continuous
3.  $\pi g$ -continuous
4.  $g$ -continuous
5.  $g b$ -continuous
6.  $\pi g r$ -continuous
7.  $\pi g b$ -continuous
8.  $\pi g s$ -continuous
9.  $r g$ -continuous
10.  $g^*\pi$ -continuous
11.  $g p$ -continuous
12.  $g\alpha$ -continuous
13.  $\alpha g$ -continuous
14.  $g$ -semicontinuous

**Remark 3.29.** The composition of two  $\hat{g}\pi$ -continuous functions need not be a  $\hat{g}\pi$ -continuous as seen from the following example.

**Example 3.30.** Let  $X = Y = Z = \{a_1, b_1, c_1\}$  with  $\tau = \{X, \varphi, \{b_1\}, \{c_1\}, \{b_1, c_1\}\}, \sigma = \{Y, \varphi, \{b_1\}, \{a_1, b_1\}\}$  and  $\gamma = \{Z, \varphi, \{a_1\}, \{a_1, b_1\}, \{a_1, c_1\}\}$  be topologies on  $X, Y$  and  $Z$  respectively. Let  $f : X \rightarrow Y$  be defined by  $f(a_1) = c_1, f(b_1) = b_1, f(c_1) = a_1$  and  $g : Y \rightarrow Z$  be defined by  $g(a_1) = b_1, g(b_1) = a_1, g(c_1) = c_1$ . Then the functions  $f$  and  $g$  are  $\hat{g}\pi$ -continuous but their composition  $g \circ f : X \rightarrow Z$  is not  $\hat{g}\pi$ -continuous, since for the only closed set  $a_1, b_1$  in  $Z, (g \circ f)^{-1}(b_1) = \{c_1\}$  is not  $\hat{g}\pi$ -closed in  $X$ .

**Theorem 3.31.** If  $f : X \rightarrow Y$  be  $\hat{g}\pi$ -continuous and  $g : Y \rightarrow Z$  is continuous, then the composition of two function is  $\hat{g}\pi$ -continuous.

**Proof.** Let  $h = f \circ g$  and  $V$  be a closed set in  $Y$ . Since  $g$  is continuous,  $g^{-1}(V)$ -closed in  $Y$ . Since  $f$  is  $\hat{g}\pi$ -continuous,  $f^{-1}g^{-1}(V) = (g \circ f)^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$ . Therefore  $(g \circ f)$  is  $\hat{g}\pi$ -continuous

**Theorem 3.32.** Let  $f : X \rightarrow Y$  be a  $\hat{g}\pi$ -continuous function, then for every subset  $A$  of  $X, f(\hat{g}\pi cl(A)) \subseteq cl(f(A))$ .

**Proof.** Let  $f : X \rightarrow Y$  be a  $\hat{g}\pi$ -continuous function and  $A$  be any subset of  $X$ . Then  $cl(f(A))$  is a closed set in  $Y$ . Since  $f$  is  $\hat{g}\pi$ -continuous,  $f^{-1}cl(f(A))$  is  $\hat{g}\pi$ -closed in  $X$ . Since  $f(A) \subseteq cl(f(A)), A \subseteq f^{-1}(cl(f(A)))$ . Therefore,





### Vijayalakshmi and Thiripurasundari

$f^{-1}(cl(f(A)))$  is closed set containing  $A$ . By the definition of  $\hat{g}\pi$ -closure,  $\hat{g}\pi(A) \subseteq f^{-1}(cl(f(A)))$  which implies that  $f(\hat{g}\pi cl(A)) \subseteq cl(f(A))$ .

**Theorem 3.33.** Let  $f : X \rightarrow Y$  be a function then  $f$  is  $\hat{g}\pi$ -continuous if and only if the inverse image of every open set in  $Y$  is  $\hat{g}\pi$ -open in  $X$ .

**Proof.** Assume that  $f$  is  $\hat{g}\pi$ -continuous. Let  $U$  be an open set in  $Y$ . then  $U^c$  is closed in  $Y$  which implies that  $f^{-1}(U^c) = X - f^{-1}(U)$  is  $\hat{g}\pi$ -closed in  $X$ . Therefore  $f^{-1}(U)$  is  $\hat{g}\pi$ -open in  $X$ . Conversely, let us assume that the inverse image of every open set in  $Y$  is  $\hat{g}\pi$ -open in  $X$ . let  $V$  be any closed set in  $Y$ . then  $V^c$  is open in  $Y$ . Since  $f^{-1}(V^c)$  is  $\hat{g}\pi$ -open in  $X$ , but  $f^{-1}(V^c) = X - f^{-1}(V)$  is  $\hat{g}\pi$ -open in  $X$ . Therefore  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$ . Hence  $f$  is  $\hat{g}\pi$ -continuous.

#### 4 $\hat{g}\pi$ -irresolute function

**Definition 4.1.** A function  $f : X \rightarrow Y$  is said to be  $g\pi b$ -irresolute if  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed set in  $X$  for every  $\hat{g}\pi$ -closed set  $V$  in  $Y$ .

**Theorem 4.2.** Every  $g\pi b$ -irresolute function is  $g\pi b$ -continuous.

**Proof.** Let  $f : X \rightarrow Y$  is  $g\pi b$ -irresolute function. let  $V$  be  $g\pi b$ -closed in  $Y$ . Then  $V$  is closed in  $Y$  and therefore  $f^{-1}(V)$  is  $g\pi b$ -closed in  $X$ . Hence  $f$  is  $g\pi b$ -continuous.

**Remark 4.3.** The converse of above theorem need not be true as seen from the following example

**Example 4.4.** Let  $X = Y = \{a_1, b_1, c_1\}$ ,  $\tau = \{X, \varphi, \{a_1\}, \{a_1, b_1\}\}$  and  $\sigma = \{Y, \varphi, \{a_1\}, \{c_1\}, \{a_1, c_1\}\}$ . Let  $f : X \rightarrow Y$  be an identity function. Then  $f$  is  $g\pi b$ -continuous but not  $g\pi b$ -irresolute function.

**Theorem 4.5.** Let  $f : X \rightarrow Y$  and  $g : Y \rightarrow Z$  be two  $g\pi b$ -irresolute functions. Then their composition  $g \circ f : X \rightarrow Z$  is a  $g\pi b$ -irresolute function.

**Proof.** Follows from the definitions.

**Theorem 4.6.** Let  $f : X \rightarrow Y$  be a  $\hat{g}\pi$ -irresolute function and  $g : Y \rightarrow Z$  be a  $\hat{g}\pi$ -continuous function. Then their composition  $g \circ f : X \rightarrow Z$  is a  $\hat{g}\pi$ -continuous function.

**Proof.** Let  $V$  be any closed set in  $Z$ . Since  $g$  is  $\hat{g}\pi$ -continuous,  $g^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $Y$ . Since  $f$  is  $\hat{g}\pi$ -irresolute,  $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$ . Hence  $g \circ f : X \rightarrow Z$  is a  $\hat{g}\pi$ -continuous function.

**Theorem 4.7.** Let  $f : X \rightarrow Y$  be a  $\hat{g}\pi$ -irresolute, then for every subset  $A$  of  $X$ ,  $f(\hat{g}\pi cl(A)) \subseteq cl(f(A))$ .

**Proof.** Let  $f : X \rightarrow Y$  be a  $\hat{g}\pi$ -irresolute and  $A$  be any subset of  $X$ . Then  $cl(f(A))$  is a closed set in  $Y$ . Since  $f$  is  $\hat{g}\pi$ -irresolute,  $f^{-1}cl(f(A))$  is  $\hat{g}\pi$ -closed in  $X$ . Since  $f(A) \subseteq cl(f(A))$ ,  $A \subseteq f^{-1}(cl(f(A)))$ . Therefore,  $f^{-1}(cl(f(A)))$  is closed set containing  $A$ . By the definition of  $\hat{g}\pi$ -closure,  $\hat{g}\pi cl(A) \subseteq f^{-1}(cl(f(A)))$  which implies that  $f(\hat{g}\pi cl(A)) \subseteq cl(f(A))$ .

**Theorem 4.8.** Let  $f : X \rightarrow Y$  be a function then  $f$  is  $\hat{g}\pi$ -irresolute if and only if  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed set in  $X$  for every  $\hat{g}\pi$ -closed set  $V$  in  $Y$ .

**Proof.** (Necessary) : Let  $f : X \rightarrow Y$  be a  $\hat{g}\pi$ -irresolute function. Let  $V$  be any  $\hat{g}\pi$ -closed set in  $Y$ . Then  $(Y - V)$  is  $\hat{g}\pi$ -open in  $Y$ . Since  $f$  is  $\hat{g}\pi$ -irresolute,  $f^{-1}(Y - V) = X - f^{-1}(V)$  is  $\hat{g}\pi$ -open in  $X$  and hence  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$ .

(Sufficiency) : Assume that  $f^{-1}(V)$  is  $\hat{g}\pi$ -closed in  $X$  for each  $\hat{g}\pi$ -closed set  $V$  in  $Y$ . Let  $U$  be any  $\hat{g}\pi$ -open set in  $Y$ . Then  $(Y - U)$  is a  $\hat{g}\pi$ -closed set in  $Y$ . By hypothesis,  $f^{-1}(Y - U)$  is a  $\hat{g}\pi$ -closed set in  $X$ . That is  $f^{-1}(Y - U) = X - f^{-1}(U)$  is a  $\hat{g}\pi$ -closed set in  $X$  which implies that  $f^{-1}(U)$  is a  $\hat{g}\pi$ -open set in  $X$ . Hence  $f$  is a  $\hat{g}\pi$ -irresolute map.

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**Vijayalakshmi and Thiripurasundari**

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## Protocol on a Systematic Review and Meta-Analysis of Qualitative Studies on Diabetes Peripheral Neuropathy Treatment Challenges Experienced by Diabetes Patients

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### ABSTRACT

Diabetes Peripheral Neuropathy (DPN) is the most prevalent type of neuropathy in worldwide. Elderly people and adults with long-term diabetes have a greater risk for DPN. Most estimates indicate that throughout the course of their lifetime, DPN will affect roughly 50% of persons with diabetes. If the condition is not properly and successfully managed, it may present numerous challenges. This systematic review will collate challenges experienced on DPN treatment and strategies that have been employed to address these challenges. The study will answer the following questions: (i) what challenges have been experienced in the treatment of DPN? and (ii) what strategies have been used to overcome DPN treatment challenges? Google Scholar, Scopus, and PubMed databases will be searched for the studies published between January 2015 to June 2023 to evaluate challenges to DPN treatment and strategies to overcome these challenges. After screening article titles and abstracts according to eligibility, two independent reviewers will examine the entire texts of the chosen studies. The quality of the included studies will be evaluated using the Joanna Briggs checklist for qualitative research appraisal tool in addition to standard data extraction forms. Results will be reported according to the Enhancing transparency in reporting the synthesis of qualitative research (ENTREQ) and qualitatively synthesised using the framework synthesis approach. This systematic review will collate challenges experienced on







Manu Goyal and Rittu Sharma

DPN treatment and strategies that have been employed to address these challenges. The findings will also be used as an input for decision makers and policy formulators to plan and implement evidence-based strategies to solve challenges experienced in DPN treatment. PROSPERO- CRD42023445185 (Registered on 24/07/2023).

**Keywords:** Diabetes Peripheral Neuropathy, Treatment, Experiences, Challenges.

## INTRODUCTION

Globally and in developing nations like India, the burden of diabetes is large and rising, primarily due to rising rates of overweight/obesity and unhealthy lifestyles. The World Health Organization (WHO) reports that non-communicable diseases (NCDs) caused 71% of deaths worldwide in 2019; diabetes accounted for 1.6 million of those fatalities, making it the tenth greatest cause of death worldwide. In India, 77 million people were estimated to have diabetes in 2019, and by 2045, that number is projected to reach over 134 million. Previously thought to be a disease of the wealthy "Western" nations, type 2 diabetes, which accounts for 90% of all cases of diabetes, has spread globally and is now a leading cause of disability and mortality that affects increasingly younger age groups.[1-4] One of the main complications of the diabetes mellitus is Diabetes Peripheral Neuropathy (DPN). DPN may be defined as a nerve damaging disorder associated with diabetes mellitus (DM) resulting from micro vascular or macro vascular insult that further progress severe abnormalities. In comparison to Type 1 DM, DPN is observed to be more frequently related with Type 2 diabetes mellitus (DM) (90–95%). Elderly people and adults with long-term type 1 or type 2 diabetes have a greater risk for diabetic peripheral neuropathy. Most estimates indicate that throughout the course of their lifetime, diabetic peripheral neuropathy will affect roughly 50% of persons with diabetes. The chronic sensori motor diabetes peripheral polyneuropathy (CSMDPN) is the commonest (70%) seen in individuals with DM. The clinical manifestations of CSMDPN are neuropathic pain and development of foot ulcers. Impaired balance, gait, joint position sense, ankle range of motion, muscular tightness and altered mechano sensitivity of the peripheral nerves have found to be associated with CSMDPN. It affects distinct parts of the nervous system with a variety of clinical symptoms. DPN has an around 50% lifetime prevalence rate.

Both Type 1 and Type 2 diabetes patients experience significant morbidity and mortality due to DPN, which affects the peripheral and autonomic nerve systems. Insidious peripheral nerve damage can start with sensory abnormalities and progress to motor dysfunction.[4-7] According to WHO, Diabetes prevalence is rising most quickly in low- and middle-income nations. The major factors of the global rise in the diabetes epidemic include fast socioeconomic change, urbanization, and industrialization, with other risk factors like increasing population, unhealthy eating patterns, and a sedentary lifestyle also playing a significant part. Several factors are reported to determine the challenges experienced by DPN patients. Low levels of knowledge, negative attitudes and practices by DPN patients also remain as pertinent factors hindering access to quality diabetic care.[1,8] The quality of services is also an important determinant in deciding to utilise or achieve DPN treatment. There are many studies on treatment of DPN but no qualitative review till now which specifically focus on challenges of DPN treatment and solutions to these challenges. The knowledge of these DPN treatment challenges will be useful for the patients with DPN. The challenges for treatment of DPN may adversely influence treatment outcomes for DPN patients and their quality of life. therefore, need to better understand the challenges to treatment of DPN patients in order to improve their quality of life. This will enable the creation of supportive environments for DPN patients which seek to encourage them to access treatment and services more readily. Through the proposed systematic review, we will collate challenges experienced on DPN treatment and strategies that have been employed to address these challenges. The findings will also be used as an input for decision makers and policy formulators to plan and implement evidence-based strategies to solve challenges experienced in DPN treatment. Therefore, this systematic review will explore challenges experienced in DPN treatment and strategies that can be instituted to address these challenges. The study



**Manu Goyal and Rittu Sharma**

will set out to answer the following questions: (i) what challenges have been experienced in the treatment of DPN? and (ii) what strategies have been used to overcome DPN treatment challenges?

**METHODS**

Enhancing Transparency in Reporting the Synthesis of Qualitative Research (ENTREQ) Statement will be used in this systematic review protocol. This protocol has been registered on the Prospero database with reference no. CRD42023445185. To make sure that a similar systematic review study protocol had not already been registered, PROSPERO was also checked. No earlier research on our topic of concern has been recognized.

**Study design**

To identify and synthesise the peer-reviewed publications for evidence in this field and to develop a coherent empirical research plan that builds on prior knowledge, a systematic review of the current evidence on challenges associated in the treatment of DPN is considered as a viable method.[9] In order to create an interpretation based on people's perspectives and experiences, this evaluation will solely use qualitative information. This acknowledges the rich background and various dimensions of the challenges from the perspective of persons experiencing these challenges. Furthermore, a synthesis of qualitative data attempts to produce conclusions that are pertinent, suitable, and meaningful to individuals, to guide a research agenda, and eventually to more successfully influence policy and practices on the quality of care for DPN patients. The review will collect, integrate, and evaluate the data from the included studies using qualitative synthesis techniques (see the "Study Eligibility Criteria" and "Data Synthesis and Analysis" sections). The evaluation aims to go beyond the collection of available data to offer further interpretive insights into the challenges and solutions to these challenges in the management of DPN and to identify areas where future research can advance current knowledge.[10,11]

**Study eligibility criteria**

The review will include qualitative peer-appraised studies. A qualitative component will be assessed for relevance before being incorporated in case studies, mixed methods studies, phenomenological studies, grounded theory and ethnographic approaches. Additionally, any study that includes thematic analysis as well as qualitative data analysis techniques such as individual and focus group interviews for collecting data will be considered. All peer-reviewed studies that discuss the challenges associated with the treatment of DPN from the perspectives of patients, families, and healthcare professionals will be included. Studies describing ways to overcome these challenges in order to enhance the effectiveness of DPN treatment will also be included. Studies have to be published between January 2015 and June 2023 in order to be included for the review, enabling the identification of emerging difficulties from a wide range of perspectives. The Population, Intervention, Comparison, Outcome, Study design (PICOS) framework will be used for the eligibility criteria during the initial literature search.

**Study participants**

The review will contain all research that discuss the difficulties in treating DPN from the views of patients, families, healthcare workers that we will come across in the studies on these difficulties and their solutions. According to the World Health Organization (WHO), healthcare professionals are all individuals engaged in activities with the primary goal of promoting health.

**Type of Interventions**

Studies focusing on medical, physical and psychosocial interventions in hospitals, homes and communities for treating DPN will be included in our review to evaluate its applicability and help in determining issues and potential solutions. Any qualitative study that analyzes these challenges experienced during the treatment of DPN and those that provide solutions will be included. The term "challenges" will be used broadly to refer to "any factor or attribute which leads to inadequate control of DPN."





**Manu Goyal and Rittu Sharma**

**Comparison**

No comparator will be taken into consideration for the review due to the methodological unsuitability of the research design.

**Types of outcome measures**

The challenges in treating DPN that patients, families, and healthcare professionals confront, as well as the solutions to these challenges, are the phenomena of concern in this review.

**Study exclusion criteria**

The reviewers will not include any research that are not available in English, abstracts from conferences, or other types of literature, or editorial remarks. Studies that simply provide quantitative data (such as case control, cross-sectional, cohort studies, and clinical trials) will be omitted.

**Search strategy**

To create a comprehensive database we will include all the published research studies addressing the challenges for the treatment of DPN and solutions to these challenges. To do this, comprehensive searches of the Google Scholar, Scopus, and PubMed databases will be searched for the studies published during the specified time frame. The search keywords will be Diabetes peripheral neuropathy, challenges, treatment, qualitative studies and related terms. All the databases will be searched using "MeSH (Medical Subject Headings) terms," "similar keywords," and "Boolean operators ("OR" and "AND") using Advanced search options." For any additional sources of information, the reference lists of all the included articles published during the specified time period will also be reviewed thoroughly. We will limit our search from January 2015 to June 2023 to evaluate challenges to DPN treatment and strategies to overcome these challenges.[12]

**Selection of study and process of data management**

The ENTREQ guidelines will be used for reporting qualitative systematic reviews to establish the selection process and findings.[13] Search strategies will be implemented and all the references retrieved will be imported to the web-based reference management system, Mendeley literature management tool. A single library will contain the search results from all pre-approved electronic databases, and duplicate records from the same reports will be deleted. The selection procedures and outcomes will be presented in accordance with the ENTREQ criteria for reporting qualitative systematic reviews.

**Quality appraisal**

During the results synthesis, all retrieved articles that are eligible for inclusion will go through a quality assessment process. Two independent reviewers (RS and MG) will evaluate the quality using the Critical Appraisal Checklist for Qualitative Research assessment tool developed by the Joanna Briggs Institute (JBI) (see Additional file 1).[14] If there are disagreements or conflicts among the reviewers, they will be handled by conversation or by involving another reviewer. This tool was made especially for systematic reviews. The findings will enable us to assess whether the studies we have included are in accordance with the standard quality assessment for articles reporting qualitative research.

**Data extraction**

Data will be independently extracted by two review authors (RS and MG) from eligible studies and input the variables related to the research population and relevant phenomena into a customized data extraction form. The two reviewers will independently verify and double-check the extracted articles. Joanna Briggs Institute (JBI) data abstraction format (see Additional file 2) will be used by the reviewers.[14] The primary author's name, the publication year, the duration of the data collection period, and the nation where the study was carried out are study parameters that will be extracted. Then, specific study information such as the study design, population, sample size, sampling procedures, and data collection methods will be reported. The factors that have been described as



**Manu Goyal and Rittu Sharma**

problems, challenges, or difficulty issue(s) with DPN treatment will be carefully identified, along with solutions to these problems. If any information requires clarification, then the primary authors will be contacted via email.

**Data synthesis and analysis**

The researchers will analyse and present findings from these clusters independently in an effort to highlight disparities between categories including patients, families, and healthcare professionals. The analysis and synthesis of data will be done using a thematic framework analysis approach.[15] Thematic synthesis can help us better understand the challenges of treating DPN and potential solutions when the data is expected to be largely descriptive. When synthesizing our qualitative data, we will adhere to the five stages of the framework synthesis process.

**Familiarisation with the data**

The primary reviewer (RS) will start familiarising with the data related to the review's objectives and take note of recurrent themes within the studies

**Identifying a thematic framework**

Instead of creating their own a priori framework, the reviewers will make use of a pre-established thematic framework that was created by the review authors using the literature to assist the thematic analysis(see Additional file 3). However, based on the recurring themes from our investigation, our evaluation will use this approach. This framework provides a thorough list of potential contributing variables to challenges and potential solutions to these challenges in DPN treatment.

**Indexing**

The retrieved data will be independently read by the two reviewers (RS, and MG) who will look for themes in accordance with a specified thematic framework and any additional emerging themes. As new themes are identified, the framework will be revised. The entire review team will agree on this through discussion. All the studies will be read until there are no new emerging themes. The data will be coded in accordance with the themes obtained in the data. Every primary study will be indexed using the codes associated with the framework themes. According to suitability parts of the studies may be indexed with one or more codes.

**Charting**

The reviewers will compile the information according to themes and show the themes in a table of analysis (chart). We will be able to compare study results across many themes and subthemes with the help of table columns and rows representing the studies and related themes.

**Mapping and Interpretation**

Charts will be used by the reviewers to map the range and nature of the phenomena and define the concepts that have been identified. In order to make the conclusions more clear, our examination will look at connections between the concepts. According to the review's objectives and emergent themes, the findings will be mapped out and interpreted.

**DISCUSSION**

This systematic review will add to what is already known by focusing attention in a new way on problems and solutions. This is seen to be an essential step in providing high-quality treatment for DPN research. The attempt to enhance the standard DPN care and a better understanding of the complex problems confronted in treating DPN will both benefit from broadening the knowledge base. While these theoretical insights into a topic area might be valuable additions to the academic evidence, it is essential to create a strong qualitative synthesis that takes the



**Manu Goyal and Rittu Sharma**

discovered evidence into consideration. The stated objectives can be effectively met, research questions can be satisfactorily answered, and policy directives can be meaningfully addressed via a framework synthesis.

**Conflict of Interest**

The authors declare that they have no conflict of interest.

**ABBREVIATIONS**

**DPN:** Diabetes Peripheral Neuropathy

**CSMDPN:** Chronic Sensorimotor Diabetes Peripheral Polyneuropathy

**ENTREQ:** Enhancing Transparency in Reporting The Synthesis of Qualitative Research

**PICOS:** Population, Intervention, Comparison, Outcome And Study Design

**JBI:** Joanna Briggs Institute

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**Manu Goyal and Rittu Sharma**

**Thematic framework analysis format for summarizing treatment challenges experienced by Diabetes Peripheral Neuropathy (DPN) patients.**

Main theme	Emerging sub-themes	DPN treatment challenges	Studies

**Additional file 3: Thematic framework**





## An Overview on Herbal Bilayered Tablets

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### ABSTRACT

Tablets with more than one layer are creative substitutes for the traditional oral medicinal administration strategy. Bilayer tablets enable the simultaneous distribution of multiple medications with different release rates by layering pharmaceuticals and polymers. These tablets have a sandwich-like appearance and can be used for sequential delivery of combination medications. They are suitable for antihypertensive, diabetic, anti-inflammatory, analgesic, and antibiotic medicines. Bilayer tablets consist of an instant release layer and prolonged release layer, with rapid release using sodium starch glycolate and sustained release using polymers like Eudragit® RL, Eudragit® RS, and EC. Studies show that the loading dosage is released in a burst, and the remaining medication is gradually released over 12 hours. This bilayered system architecture may benefit hypertension treatment. Bilayer pills can also contain herbs, which increases their effectiveness in treating a variety of diseases by reducing the dosage frequency. Herbal medicine first became widely used in ancient times. In fact, many pharmaceutical medications today are synthetic equivalents of substances found in plants naturally. To create synergistic effects, increase bioavailability, physically distinguish incompatible substances to avoid interactions, and promote the development of various drug release profiles, bilayer may be the only approach that has





Karra Geetha *et al.*,

been put forward in many APIs. This paper's objectives are to provide a thorough overview on bilayer tablet innovation, emphasise the difficulties encountered, and to offer potential solutions.

**Keywords:** Bilayer Tablets, Eudragit® RL, Eudragit® RS, antihypertensive, diabetic, anti-inflammatory, analgesic.

## INTRODUCTION

The innovative technology for the creation of controlled release formulations is the herbal bilayer tablet. A bilayer tablet is created by combining two or more Active Pharmaceutical Ingredients (API) in a single dose form. The usage of herbal bilayered tablets has grown recently. For the treatment of a wide range of illnesses and disorders requiring long-term care, such as diabetes, both industrialised and developing nations are moving towards combination therapy. More than 90% of today's produced formation is consumed orally.(1,2).

The bilayer tablet is a more recent dosage form that is superior to those that have been in use in the past for the successful development of controlled release formulations. Bilayer tablets can separate two types of incompatible substances and are appropriate for the sequential release of two medications when taken in conjunction. They can also be used to create sustained release tablets, where the first layer is an immediate release dose and the second layer is a maintenance dose. Bilayered tablets occasionally feature two layers of sustained-release medication.(3,4) The biphasic technique is typically employed when immediate maximal relief is required, and it is immediately followed by a continuous release phase. It also prevents a medicine from being administered repeatedly.(5).

The simultaneous distribution of one or two medications with various release rates is made possible by the cutting-edge tablet technology known as bilayer tablets. One rate-controlling polymer may be manipulated to deliver several medications by layering different pharmaceuticals and polymers (6). They have a sandwich-like appearance because each layer's exposed edges. The best option for bypassing chemical-based complications across APIs and enabling the creation of various drug release patterns may be bi-layer tablets. For the sequential delivery of two combination medications, bi-layer tablets are suitable. In sustained-release pills, the loading dosage is found in the first layer, and the maintenance dose is found in the second layer. (7) Since these medications usually need combination therapy to be successful, the usage of bilayer tablets for antihypertensive, diabetic, anti-inflammatory, analgesic, and antibiotic medicines is significantly different.(8). The bilayer tablet is a flexible byproduct of monolithic partly coated or multiple-layered matrices. By placing the medication in the top non-adhesive layer of bi-layered tablets, where it is conveyed throughout the oral cavity, medication release may be rendered almost unidirectional. (9).

### NEED OF BILAYERED TABLETS :(10, 11)

- Create innovative drug delivery systems including chewing devices and floating tablets for gastro-retentive drug delivery in order to extend the life cycle of drug products that are administered in fixed dose combinations of various API.
- Controlling the pace at which one or two active medicinal components are delivered.
- To create swellable/erodible barriers for modified release by altering the total surface that is available for the API layer by sandwiching it between one or two active layers.
- To isolate incompatible active pharmaceutical ingredients (APIs) from one another so that the functional feature of the other layer (such as the osmotic property) can be used to control the release of API from one layer.

### OBJECTIVES OF BILAYERED TABLETS: (12-17)

- To regulate the rate at which one or two separate active medicinal components are delivered.
- Using the functional feature of the outer layer to control the release of API from one layer while separating incompatible active pharmaceutical ingredients from one another.





**Karra Geetha et al.,**

- To create swellable or erodible barriers for modified release by modifying the total surface area available for the API layer by sandwiching with one or two inactive layers.
- To provide fixed dose combinations of various active pharmaceutical ingredients, extend the lifecycle of the therapeutic product, and create novel drug delivery methods such as chewing devices for buccalmucoadhesive administration systems and floating tablets for gastro-retentive drug delivery.

#### **ADVANTAGES: (1,2,3)**

- They serve as an advancement of traditional technologies.
- Granules of feed that are one unit could be used.
- Distancing of incompatible parts.
- Patients are more compliant, which improves the effectiveness of their medication regimen.
- Due to the need for fewer daily doses than with the conventional administration system, patient compliance is increased.
- Maintain potency and guarantee correct dosage.

#### **DISADVANTAGES: (10, 18)**

- Increases complexity and the cost of bilayer rotary presses.
- Reduced yield due to insufficient hardness and layer separation.
- Inaccurate individual layer weight control.
- Layer-to-layer contamination.

#### **IDEAL CHARACTERISTICS: (11, 19)**

- It should be tasteful and free from contamination, discolouration, chipping, and cracking. When making tablets, it should be of sufficient quality to withstand mechanical shock.

#### **APPLICATION: (11, 20)**

- ❖ Bilayer tablets are appropriate for the combined sequential release of two drugs.
- ❖ A sustained release pill has two layers, the first of which is an immediate release initial dose and the second of which is a maintenance dose.
- ❖ The bilayer tablet is an enhanced technology that solves the problems of the single layer tablet.
- ❖ The loading dose and sustained dose of the same or different medications are delivered using bilayer tablets.
- ❖ Bilayer floating tablets are made of two layers, one of which is a floating layer and the other a rapid release layer for the medication.
- ❖ To administer two distinct medications with various release patterns, bilayer tablets are employed.
- ❖ Methods such as chewing devices for buccalmucoadhesive administration systems and floating tablets for gastro-retentive drug delivery.

#### **TYPES OF BILAYERED TABLETS: (21)**

- Homogenous type
- Heterogenous type

#### **HOMOGENOUS TYPE**

When a drug's release characteristics required dual release or its release pattern differed from one another, bilayer tablets were preferred. Bilayer tablets enable the design and modification of the dissolution rate and release characteristics so that the immediate release layer serves as a loading dosage of the medication and the second layer serves as the second dose, releases later, or falls under an extended release.

#### **HETEROGENOUS TYPE**

The sequential release of two medications in combination and the separation of two incompatible compounds are both suited for bilayer tablets.





Karra Geetha *et al.*,

It's critical to choose a bi-layer tablet press with the following capabilities in order to create a quality bi-layered tablet in a certified and GMP manner:

- High yield
- Preventing the bilayer tablet's two layers from capping and separating from one another.
- Keeping the two layers from becoming contaminated with one another.
- Creating a divide between the two levels that is clearly noticeable.

#### DIFFERENT DRUG DELIVERY SYSTEM USED IN BILAYER TABLETS: (22)

**Floating drug delivery system:** One type of gastro retentive drug delivery device is the floating drug delivery system. These systems stay in the stomach for several hours, considerably extending the duration that medications stay in the stomach. With this approach, bioavailability is enhanced. These systems can increase the solubility of medications that are less soluble in high pH environments. There are two different kinds of floating drug delivery methods for bilayer tablets:

- Intragastric bilayer floating tablet
- Multiple unit type floating tablet

Compressed bilayer floating tablets are meant to stay in the stomach or gastric region and provide the desired therapeutic effects. As opposed to this, multiple unit type floating tablets are systems that use prolonged release pills as "seeds" that are encircled by two layers. While the inner layers contain effervescent chemicals, the outer layer is a membrane that can inflate. Due to their low density, they float in the body as enlarged pills that resemble balloons. It is also referred to as a distribution system with a multi-particulate floating reservoir.

**Polymeric bioadhesivesystem :** The situation in which two materials are held together for long periods of time by interfacial forces is known as bio-adhesion. Bucco adhesive or mucoadhesive polymeric bio-adhesive bilayer tablets are both available. Tablets with a mucoadhesive bilayer stick to the stomach mucosa and release the active medicinal components over time. These pills can stay in the stomach for several hours, extending the medicines' time in the stomach. These have improved bioavailability as a result of prolonged stomach retention. Mucoadhesive systems have the potential to be used as drug carriers because they can increase contact with the epithelial barrier by extending their stay at the absorption site.

The removal of preparation by the body's natural defensive system, the mucociliary clearance system, is a drawback of such systems. However, mucoadhesive qualities combined with bilayer tablets have added benefits like high bioavailability, effective absorption, and close contact with the mucous layer. The medicine is released in the buccal cavity using buccoadhesive bilayer tablets, which also prevent first pass metabolism and increase bioavailability. A drug carrier polymer and other excipients interact with the mucin on the surface of the buccal mucosa to form a buccoadhesive system. This system has a number of benefits, including the ability to self-place and remove devices and skip first pass metabolism. To be kept in the mouth cavity for the necessary amount of time, a viable buccal drug delivery system must have strong bio-adhesive qualities.

**Swelling system :** Swelling systems are made to quickly expand or swell after intake to release medication to the precise level that is needed. When administered, they are just the right size because they enlarge once inside the body. They could have an instant release layer with a longer release or an immediate layer underneath. To exit the stomach, the system progressively breaks down into tiny particles.

#### DRUGS AND POLYMERS

In bilayered systems, it is typical to have an amount of medicine for quick release in the first layer and a quantity for delayed release in the second layer. After delivery, the quick release layer dissolves, while the matrix layer holds together as the medication travels through the gastrointestinal system.





**Karra Geetha et al.,**

In order to keep blood levels stable, the matrix erodes gradually. This delivery system may also include two medicines for varying release characteristics. Patra and coworkers created a bilayered tablet to administer propranolol hydrochloride. An instant release layer and prolonged release layer comprises these tablets. The rapid release layers of different formulations used sodium starch glycolate as the super disintegrant, whereas the sustained release layers used polymers like Eudragit® RL, Eudragit® RS, and EC. Studies on drug release showed that the loading dosage was first released in a burst, and then the remaining medication was gradually released over a period of 12 hours.(6)

In a patent filed by Kim and colleagues, the same idea was illustrated by a system that allowed for the delivery of two medications in various ways. Metformin was administered through the controlled release layer, and glimepiride by the fast release layer. The immediate release layer included glimepiride and a disintegrant, whereas controlled release layer included a combination of a hydrophobic and hydrophilic polymers. (23) This highlights even more how effective these systems are in managing chronic diseases like diabetes and hypertension. In order to treat hypercholesterolemia concurrently, Nirmal and colleagues created a bilayered tablet combining both nicotinic acid and calcium atorvastatin for rapid release. It has been demonstrated that taking these two medications together significantly lowers cholesterol found in low-density lipoprotein and alters cholesterol found in high density lipoprotein in ways that are beneficial. The instant release layer containing atorvastatin calcium was created utilising the super disintegrant, croscarmellose sodium, and used Methocel® K100M as the polymeric matrix for nicotinic acid. These tablets remained successful in simultaneously delivering two different types of medicines, according to drug release trials done over a period of 12 hours<sup>10</sup>. Thus, the effective treatment of hypertension may someday benefit from the use of this bilayered system architecture. (24)

#### **IMPORTANCE OF HERBS IN BILAYERED TABLET TECHNOLOGY:**

To provide a synergistic effect and improve therapeutic advantages, different herbal substances are combined to create herbal bilayer tablets. The choice of herbal components is influenced by the intended usage and expected therapeutic outcomes. The following list of typical herbal components can be found in herbal bilayer tablets:

#### **FENUGREEK (*Trigonella foenum-graecum*): (25)**

Fenugreek is a herb that has been used for ages for its medicinal benefits; its scientific name is *Trigonella foenum-graecum*. It is nutrient- and compound-rich and has several positive health effects. We have used fenugreek for its health-promoting properties and capacity to treat a range of diseases, including digestive disorders, skin conditions, hair problems, and leg weakness, since ancient times. Fibres, iron, manganese, magnesium, and plant-based proteins are all abundant in fenugreek seeds. Some of the health advantages of methi seeds include the following:

- **Boost testosterone (sex hormone) secretion:** Men are more affected than women by testosterone insufficiency or hypogonadism, which can also have negative effects on mood, diabetes, obesity, bone health, and energy levels. More research is needed to confirm that fenugreek seeds naturally restore testosterone levels.
- **Reduce cholesterol levels :** Methi seeds dramatically lower blood total cholesterol levels and enhance heart health by lowering cholesterol levels.
- **Reduce high blood sugar levels :** Fenugreek seeds lower haemoglobin A1c and blood sugar levels, which lowers excessive blood sugar levels.
- **Anti-inflammatory effects :** Flavonoid antioxidants, which are found in Methi seeds, have anti-inflammatory qualities that help combat many chronic inflammatory disorders like asthma.

#### **CURRY LEAVES (*Murraya koenigii*):(26)**

Curry leaves are the foliage of the curry tree. The leaves of this tree, which is native to India, are utilised for both culinary and medicinal uses. They have a strong citrus flavour and are especially fragrant. Curry leaves, the important fragrant component in Indian cuisine, are full of health-improving nutrients. Curry leaves are incredibly rich in essential elements like magnesium, iron, calcium, phosphorus, fibre, and copper. By include curry leaves in







Karra Geetha et al.,

your meals, you can help alleviate conditions including nausea, morning sickness, diabetes, diarrhoea, and dysentery. Curry leaves frequently aid in the body's removal of toxins and fat. Some of the health benefits of curry leaves include :

- **Helps in lower cholesterol level** : One's blood cholesterol levels can be lowered thanks to the characteristics of curry leaves. These plants, which are rich in antioxidants, stop the oxidation of cholesterol, which results in the production of LDL (bad cholesterol). By increasing HDL levels, this lowers the risk of developing atherosclerosis and heart disease.
- **Boosts digestion** : Since ancient times, curry leaves have been used for their ability to aid in digestion. According to Ayurveda, kadipatta contains mild laxative effects that aid the stomach in eliminating extra waste.
- **Hastens hair growth** : Curry leaves are particularly effective at treating damaged hair; they give limp hair bounce, strengthen the fragile hair shaft, and stop hair from falling out. In addition, the leaf extract has shown antifungal efficacy against *Malassezia furfur* fungal scalp infection, which is why it can be used to treat dandruff.
- **Anti-Diabetic properties** : Curry leaves may be able to control diabetes, which is one of their many health advantages. Insulin-producing pancreatic cells can be activated and protected by consuming curry leaves.
- **Promotes weight loss** : Curry leaf is a useful plant for weight loss. It is among the greatest methods for removing the body's stored fat. According to studies, curry leaves can lower triglycerides and cholesterol levels, which prevents obesity.

#### **Giloy (*Tinospora cordifolia*): (27)**

Native to India, the climbing shrub *Tinospora cordifolia*, also known as "Guduchi" in Sanskrit, may be found at higher elevations (up to 1000 feet) in deciduous and dry woods. It is a well-known and widely-distributed traditional plant with typical summer-blooming greenish-yellow flowers and winter-blooming fruits. In Ayurvedic medicine, its leaves, stems, and roots are used to cure a variety of illnesses. Guduchi has been used and discussed for thousands of years in Ayurvedic medicine, making it one of the most highly revered herbs in the system. Guduchi (Giloy) is regarded as one of the three Amrit plants in Ayurvedic treatment. It is also one of the plants that the pharmaceutical industry uses the most commercially.

Guduchi is attracting the attention of researchers from all over the world due to its potent medicinal properties, which include anti-oxidative, anti-hepatoprotective, immunomodulatory, anti-inflammatory, anti-diabetic, anti-periodic, anti-spasmodic, anti-arthritis, anti-allergic, anti-stress, anti-leprotic, anti-malarial, anti-diarrheal, and anti-neoplastic effects. The plant provides an abundant source of protein and minerals including calcium, phosphorus, iron, zinc, and manganese. Alkaloids, steroids, diterpenoid lactones, aliphatic, and glycosides are only a few of the active substances found in *Tinospora cordifolia*. These substances are extracted from the plant's various portions. These plant extracts are widely utilised in several herbal remedies for the treatment of various illnesses.

Since ancient times, guduchi has been used in traditional ayurvedic medicine to treat a wide range of illnesses, including hay fever, diabetes, high cholesterol, jaundice, chronic diarrhoea, dysentery, gout, cancer, bone fracture, pain, asthma, scabies (an itchy skin infection brought on by mites), skin disease, poisonous insect, snake bite, eye disorders, and more. According to Ayurveda, guduchi has the following effects: it stimulates the appetite, quenches the thirst, improves strength, prolongs life, is aphrodisiac, improves sexual potency, purifies sperm, purges the blood, eliminates toxins, lessens discomfort, and is rejuvenative.





Karra Geetha *et al.*,

#### FLAX SEEDS (*Linum usitatissimum*): (28)

It should come as no surprise given their numerous health advantages. One of the most important flaxseed benefits when considering the advantages is weight loss. But there are a lot more advantages as well, which we shall go into more depth. Some of the health benefits given here are :

- **Lower the risk of cancer** : Lignans are plant chemicals with estrogenic and antioxidant effects, and flaxseeds are highly high in them. These substances are incredibly helpful in enhancing general health and are known to lessen the chance of acquiring several forms of cancer. Flax seeds contain up to 800 times more lignans than other plant-based diets.
- **Lower cholesterol level** : One of flax seeds advantages is that they can reduce cholesterol levels. It's because of how much fibre they contain. According to a research, patients with high cholesterol may observe a 17% drop in their cholesterol levels after consuming flaxseed powder every day for three months. The "bad" LDL cholesterol levels may decrease by over 20% at the same time.
- **Lower risk of diabetes** : The next food that people with diabetes should include in their diet is flax seeds. It is because flax seeds contain fibre, which may reduce blood sugar levels. According to research, the insoluble fibre in flax seeds might delay the absorption of sugar into the blood. Consequently, it could aid in lowering blood sugar levels.
- **Other health benefits** : Omega-3 fatty acids and lignans in flax seeds give them their anti-inflammatory qualities. Lignans also assist in lowering the risk of heart disease and the metabolic syndrome. This is as a result of their lowering blood sugar and fat levels. Since flax seeds contain both tryptophan and omega-3 fatty acids, they can also increase your serotonin levels.

#### MANUFACTURING PROCESS OF BILAYER TABLET

Tablet breaking force and the tablet's propensity for delamination/capping either during manufacturing or during storage need to be carefully observed. Manufacturing processes such as wet granulation/roller compaction and addition of binders increase the level of complexity in understanding the critical factors governing compression and tablet breaking force. Apart from the critical material attributes of individual components and final blend, the tablet press has large influence on the manufacture of multilayer tablets. The level of precompression force, punch velocity, consolidation time (time when punches are changing their vertical position in reference to the rolls as the distance between the punch tips are decreased), dwell time (time when punches are not changing their vertical position in reference to the rolls), relaxation time (time when both punches are changing their vertical position in reference to the rolls as the distance between the punch tips increases before losing contact with the rolls), and the applied force can have significant effect on the critical quality attributes of the tablet. In the die cavity, for example, punch velocity and compaction pressure had an effect on the degree of compact densification and resistance to compressibility. (29)

#### Compaction

Certain conditions, including the required mechanical strength and desirable drug release profile, must be satisfied in order to manufacture an appropriate tablet formulation.

When making bilayer tablets using the double compression process, it can be challenging to attain these conditions because of the drug's poor flow and compatibility characteristics, which can lead to capping and/or lamination. Compressibility and consolidation are both factors in a material's compaction.

#### Compression

In order to reduce bulk volume, gaps must be filled and particles must make closer contact with one another.

#### Consolidation

It is a characteristic of the substance wherein there is an increase in mechanical strength as a result of interparticulate contact (bonding). Tablet delamination was shown to be mostly influenced by the compression stress on layer one.

#### Compression

Since the material in the die cavity is compressed twice to create a bi-layer tablet, layer one is compressed first followed by both layers, the compression force has an impact on the adhesion and interfacial contact between the two layers. It is necessary for particle interlocking and adherence with the second layer that the first layer's surface

70617





Karra Geetha *et al.*,

be somewhat rough. A region of contact for the second layer at the interface is dramatically decreased when the degree of surface roughness of the first layer decreases, which weakens the adhesion. The level of compression force employed in the first layer compaction dictates the degree of surface roughness of the first layer, which may lead to capping or delamination of the tablet along the interface during manufacture or right away.

The surface roughness decreases as the compression force of the first layer increases, which reduces adhesion with the second layer. As a result, for a given ultimate compression force, interfacial adhesion strength diminishes as first layer compression force increases. It suggests that the strength of the interface is significantly influenced by how much the first layer has been deformed plastically or elastically. (30)

#### **TYPES OF PRESS FOR BILAYERED TABLETS: (11, 31)**

- Single side tablet press.
- Double side tablet press.
- Bilayer tablet press with displacement monitoring.
- Multilayer compression basics.

#### **SINGLE SIDE TABLET PRESS: (11, 31)**

The single-sided press's most basic configuration has the doublet feeder's chambers separated from one another. The two distinct layers of the tablets are produced by gravity- or force-feeding each chamber with a separate amount of energy. The first layer of powder and then the second layer of powder are loaded into the die as it moves beneath the feeder. The tablet is then compressed completely in one or two processes.

#### **LIMITATIONS: (32)**

- There is no weight monitoring or layer-by-layer management.
- There is no obvious visual distinction between the 2 layers.
- Dwell time because of the short compression roller may cause issues with hardness and poor deaeration capping.

#### **DOUBLE SIDED TABLET PRESS: (11, 31)**

Compression force is typically used in double-sided tablet presses with automated production control to monitor and regulate tablet weight. The main compression of the layer is where the control system applies the effective compression force to each individual tablet or layer. The signal from this recorded peak compression force is what the control system uses to reject out-of-tolerance tablets and adjust the die fill depth as necessary.

#### **LIMITATIONS: (32)**

- Only when the first layer is compressed at a low compression force, allowing this layer to still interact with the second layer during a final compression, is correct bonding achieved.
- If the first layer is squeezed with a high compression force, bonding is too constrained.
- Unfortunately, in the case of tablet presses with compression force measurement, the low compression force needed to compress the first layer decreases the accuracy of the weight monitoring/control of the first layer.

#### **ADVANTAGES: (32)**

- To prevent chapping and layer separation, a little compression force is applied to the top layer.
- Increased dwell time at first and second layer precompression to give enough hardness at top turret speed.
- Maximum cross-contamination protection between two layers.
- Between the two layers may be seen to be clearly separated.
- Monitoring of displacement weight enables precise and autonomous layer-by-layer weight management.
- Maximum yield.





Karra Geetha *et al.*,

#### **BILAYER TABLET PRESS WITH DISPLACEMENT MONITORING: (11, 31)**

The displacement pill weight control principle differs significantly from the compression force-based principle. The control is used while measuring displacement. System sensitivity is dependent on the applied pre-compression force rather than the weight of the tablet.

#### **ADVANTAGES: (32)**

- For precise independent weight management of the separate layers, displacement weight monitoring and control are used.
- To prevent chipping and the separation of the two layers, the first layer is compressed gently.
- A longer dwell time during first- and second-layer precompression to give enough hardness at the fastest turret speed.
- Cross contamination between layers is prevented to the fullest extent possible.
- Maximum yield.

#### **MULTILAYER COMPRESSION BASICS: (11, 31)**

A typical double press can be modified to accommodate multipliers, or presses can be created particularly for multilayer compression. The notion of a multilayer tablet has been used for a long time to create formulations for continuous release of drugs. These tablets often have a fast-releasing layer and may also have double or triple layers. The pharmacokinetics advantage is based on the observation that, although drug release from rapid releasing granules causes a sharp increase in blood concentration, drug release from prolonged granules results in blood levels remaining stable.

#### **VARIOUS TECHNIQUES FOR FORMULATION OF BILAYER TABLET:**

OROS® Push Pull Technology

L-OROS™ Technology

ENSOTROL Technology

DUROS Technology

PRODAS technology (Programmable Oral Drug Absorption System) (Elan Corporation)

ELAN. Drug Technologies or DUREDAS™ technology (Dual Release Drug Delivery System)

#### **OROS® Push Pull Technology**

Typically, there are two or three levels in this system, one or more of which are push layers and one or more of which are layers that are necessary to the drug. In the drug layer, there are typically two or more distinct agents in addition to the medication itself. The medication in this stratum is therefore in a poorly soluble form. Suspending and osmotic agents have also been included. Around the tablet core is a semipermeable membrane. (22)

#### **L-OROS™ Technology**

The solubility problem was handled by this system. Alza created the L-OROS system, in which a lipid soft gel product containing medicine in dissolved condition is initially generated and then coated with barrier membrane, osmotic push layer, semi-permeable membrane, and drilled with an exit orifice. (33)

#### **ENSOTROL Technology**

Enhancing the solubility by developing an ideal dosage form With a focus on the identification and implementation of the identified enhancer into controlled-releasing technologies, Shire Laboratory uses an integrated approach to medication delivery. (34)

#### **DUROS Technology**

A titanium alloy reservoir is the main component of the system. In addition to shielding the drug particles from enzymes, this reservoir offers a high impact strength. The DUROS technology is a tiny medicine delivery system that





Karra Geetha *et al.*,

resembles a tiny syringe that dispenses a little amount of concentrated medication continuously and steadily over the course of several months or an entire year.

#### **PRODAS technology (Programmable Oral Drug Absorption System)**

The controlled release minitables, which range in size from 1.5 to 4 mm in diameter, are enclosed in a multi-particulate drug delivery system. The advantages of both are demonstrated by this technology, which combines multi-particulate with hydrophilic matrix technology. To provide various release rates, minitables with various rates of release can be blended and merged into a single dosage form. These mixtures could contain minitables with regulated, delayed, or instant release. (22)

#### **ELAN. Drug Technologies or DUREDAS™ technology (Dual Release Drug Delivery System):**

An example of a bilayer tablet that uses DUREDAS™ Technology is one that may demonstrate the simultaneous or sequential release of two medications, or the simultaneous release of one drug at various speeds. A modified-release hydrophilic matrix complex and an immediate release granulate may both appear as different layers within a single tablet as a result of the tableting process. When the hydrophilic matrix of the controlled release matrix gradually absorbs fluid from the GI tract, it expands and becomes a porous, viscous gel that serves as a barrier to the controlled release of the drug. (35)

#### **BENEFITS OFFERED BY THE DUREDAS™ TECHNOLOGY (35)**

- 1) Tablets with a bilayer construction.
- 2) Customised release rates for two medication ingredients.
- 3) Combining the potential of two separate CR formulations.
- 4) The possibility to combine components with modified and immediate releases in one tablet.
- 5) Presented as a single dose tablet.

#### **CHALLENGES IN BILAYER TABLET MANUFACTURING: (36, 37, 38)**

Challenges during the development of bilayer tablets might include:

- They have inadequate hardness.
- Layer weight ratio may differ.
- Elastic mismatch of the adjacent layer may occur.
- There may be seen first layer tamping force and cross contamination between layers.
- Layer separation is the major problem in production of layered tablets.
- May be difficult to maintain integrity of final tablets.
- Production yield of bilayer tablet is very low compared to single layer tablet.
- Bilayer tablet is more expensive than single layer tablet.

These factors will negatively affect the bi-layer compression pressure as well as qualitative traits like mechanical strength and individual layer weight control if they are not sufficiently controlled in some way. In order to enable the design of a robust product and process, care must be given. Bilayer tablets can be conceptualised as two single-layer tablets combined into one, but there are a number of production issues that come with them.

#### **CLINICAL APPLICATIONS AND FUTURE PROSPECTIVES: (39)**

Pharmaceutical dosage forms known as herbal bilayer tablets include two separate layers, each of which contains a unique herbal component or formulation. These tablets provide numerous clinical uses as well as potential future developments, such as:

- **Combination therapy** : Bilayer herbal pills are a convenient way to combine several herbal substances that have complimentary or synergistic effects. This makes it possible to combine therapies into a single pill, which is useful for treating complicated medical diseases.
- **Controlled release of active compounds** : These tablets' bilayer structure can be used to provide controlled release of the active ingredients. In order to allow for longer and sustained medication administration, separate

70620





Karra Geetha et al.,

layers can be constructed to release their contents at various speeds. This may increase therapeutic efficacy and decrease the need for frequent dosing.

- **Improved patient compliance** : The benefit of mixing numerous pharmaceuticals or herbal preparations into one tablet is provided by bilayer tablets. Patients' dosage instructions can be made simpler as a result, which can enhance drug adherence and improve treatment results.
- **Targeted drug delivery** : Bilayer tablets can allow targeted medicine delivery to certain areas in the body by combining several herbal constituents or formulations in distinct layers. For instance, one layer can have components that work systemically, while the other might include components that work locally to treat illness or inflammation.
- **Standardization and quality control** : It is possible to create herbal bilayer pills that adhere to Good Manufacturing Practises (GMP) requirements. This makes it possible to standardise and improve quality control for herbal formulations, resulting in uniform dosing and therapeutic benefits.
- **Future prospects** : The use of herbal bilayer tablets is consistent with the rising demand for herbal and plant-based medications. More complex and targeted bilayer formulations are anticipated as knowledge of herbal remedies and study into them grows. Among other things, this entails investigating fresh herbal combinations, enhancing medication release profiles, and using cutting-edge technologies like nanotechnology and bioavailability augmentation methods.

#### RECENT DEVELOPMENTS IN HERBAL BILAYER TABLETS: (40, 41)

The creation of pre-determined active ingredient release patterns and the blending of incompatible active ingredients into a single unit dosage form were both made possible by the introduction of bilayer tablets to the pharmaceutical industry. In this field, several works have been completed. Some of the recent works in development of herbal bilayer tablets are given below:

- **Liv.52 DS**: Himalaya Drug Company sells the herbal bilayer tablet known as Liv.52 DS. A variety of plant extracts are combined in this hepatoprotective mix to enhance liver health and function.
- **Diabecon**: The Himalaya Drug Company makes the herbal bilayer tablet called Diabecon. It is made up of a blend of herbs that have long been used to treat diabetes in Ayurvedic therapy. It seeks to control blood sugar levels and promote good metabolic health generally.
- **Septilin**: The Himalaya Drug Company makes the herbal bilayer tablet known as Septilin. A combination of herbs having immunomodulatory and antibacterial effects are included in its formulation. It is employed to strengthen the immune system and improve respiratory health.
- **Cystone**: Herbal bilayer tablets called Cystone are produced by Himalaya Drug Company. It is made with a variety of herbs and minerals that are historically used to assist kidney stone prevention and urinary tract health.

#### CONCLUSION

A bilayer tablet is an enhanced, useful technology that addresses the drawback of a single-layered tablet. The bi-layer tablet may be used in a variety of ways; it can be made of multi layered Matrices or monolithic partly covered surfaces. Bilayer tablets can be used to segregate two incompatible substances, release two medications sequentially, and create sustained-release tablets with an immediate-release initial dosage and a maintenance dose in the second layer. The creation of multi-layered tablets is used to provide controlled release tablet preparations and methods for the delivery of incompatible medications by creating surrounding or several swelling layers. GMP regulations and bilayer tablet quality might vary greatly. This explains why a wide variety of presses, from straightforward single sided presses to very complex devices like the Courtoy-R292F, are being utilised to make bi-layer tablets. The ideal method appears to be the employment of a "air compensator" in conjunction with displacement control whenever high-quality bilayer tablets must be manufactured quickly.







Karra Geetha et al.,

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**Figure 1: *Trigonella foenum-graecum***



**Figure 2: *Murraya koenigii***





Karra Geetha et al.,



Figure 3: *Tinospora cordifolia*



Figure 4: *Linum usitatissimum*

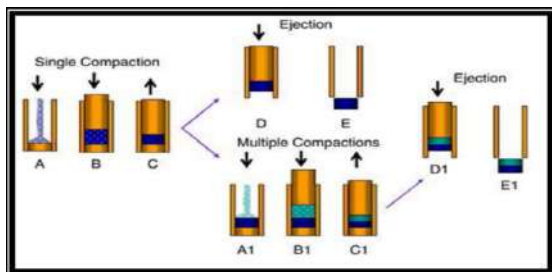


Figure 5: Bilayered tablets preparation



Figure 6: Single side tablet press



Figure 7: Double sided tablet press



Figure 8: Bilayer tablet press with displacement monitoring

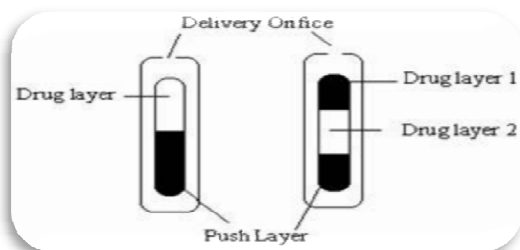


Figure 9: OROS Push Pull Technology

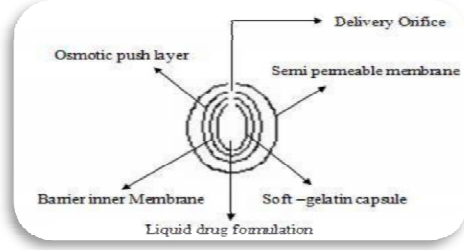
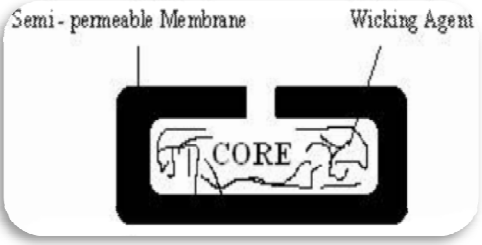
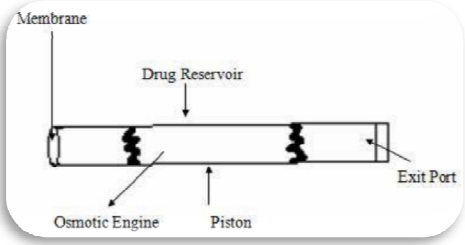
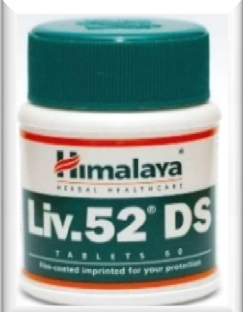


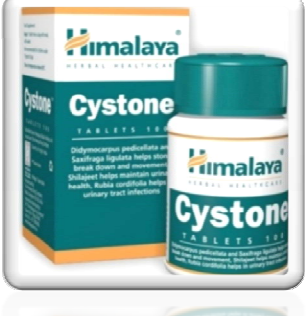


Figure 10: L-OROS™ Technology





Karra Geetha et al.,

 <p>Semi-permeable Membrane      Wicking Agent</p>	 <p>Membrane Drug Reservoir Exit Port Osmotic Engine      Piston</p>
<p><b>Figure 11: ENSOTROL Technology</b></p>	<p><b>Figure 12: DUROS Technology</b></p>
 <p>Himalaya HERBAL HEALTHCARE <b>Liv.52<sup>DS</sup></b> TABLETS 50 Pin-coated imprinted for your protection</p>	 <p>Himalaya HERBAL HEALTHCARE <b>Diabecon<sup>®</sup></b> TABLETS 50</p>
<p><b>Figure 13: Liv.52 DS</b></p>	<p><b>Figure 14: Diabecon</b></p>
 <p>Himalaya HERBAL HEALTHCARE <b>Septilin<sup>®</sup></b> TABLETS 60 Anti-infective therapy</p>	 <p>Himalaya HERBAL HEALTHCARE <b>Cystone<sup>®</sup></b> TABLETS 150 Dihydrocapsaicin, piperazine and Sesquiflora lignata helps Stone Dissolve and prevent Stone Recurrence and emergence. Shilapant helps maintain urinary health. Karka, curcumin helps urinary tract infections.</p>
<p><b>Figure 15: Septilin</b></p>	<p><b>Figure 16: Cystone</b></p>







## Development and Evaluation of A Poly herbal Cream Possessing Anti-Oxidant Properties that Aid in the Healing of Wounds

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### ABSTRACT

Wound healing is a complex process that poses significant challenges, particularly in the management of chronic wounds. Herbal formulations have emerged as promising therapeutic approaches to address these challenges and promote efficient wound healing. This study focuses on the formulation and phyto chemical screening of a poly herbal cream comprising *Lawsonia inermis*, Piper betle, and Cynodondactylon, renowned medicinal plants with demonstrated wound healing properties. The phyto chemical screening revealed the presence of diverse bioactive compounds in the extracts, including alkaloids, phenolics, tannins, carbohydrates, saponins, glycosides, and steroids, suggesting their potential bioactivity in wound healing. The poly herbal cream was developed by incorporating standardized extracts of the three plants into a suitable base. Comprehensive physicochemical assessments ensured the cream's stability, pH, viscosity, and skin compatibility for safe topical application. Additionally, an in vitro antioxidant study evaluated the wound healing potential of the cream. The findings indicated that the formulated poly herbal cream exhibited remarkable wound healing effect.

**Keywords:** *Lawsonia inermis*, Piper betle, Cynodon dactylon, Poly herbal Cream, Wound Healing.

## INTRODUCTION

A wound is a term used to describe any disturbance in the normal structural composition of the skin, mucous membrane, or tissue of an organ. Mechanical, thermal, chemical, and radiogenic traumas are all potential causes of



**Himangshu Deka et al.,**

wounds. Simple wounds that are limited to the skin are distinguished from complicated wounds that are deeper and also involve damage to muscles, nerves, and blood vessels [1].

**Wound Healing**

Healing is a complex and time-consuming process that involves the restoration of cell structure and tissue layers. It can occur through two primary mechanisms: Regeneration and Repair [2,3]. The healing process starts as soon as there has been an injury or surgery. The healing of a wound encompasses several distinct phases, which are as follows: haemostasis, the inflammatory phase, proliferation or granulation, re modelling, and scar formation [4].

**Haemostasis**

The first phase of wound healing is haemostasis, involving platelets sealing ruptured blood vessels. Platelets release vasoconstrictor chemicals to clot the vessels. With ADP, platelets stick to collagen, and thrombin converts fibrinogen into fibrin, stabilizing the clot. Platelet-derived growth factor (PDGF) initiates later healing steps. Haemostasis occurs right after injury, barring clotting disorders. [4].

**Inflammatory phase**

The inflammatory phase, the second stage of wound healing, involves the body's response to injury. Initially, blood vessels contract and clot forms. After haemostasis, arteries dilate, allowing vital components like antibodies, growth factors, white blood cells (WBCs), and crucial cells to reach the wound. This increases exudate levels. Monitor skin around the wound for softening and breakdown. Inflammation signs include redness, warmth, swelling, pain, and reduced function. Neutrophils and macrophages break down dead tissue. Growth factors like FGF, EGF, and IL-1 promote further healing. [4,5].

**Pro liferative phase**

The proliferative phase, the third stage of wound healing, involves tissue repair and regeneration. Granulation tissue, rich in collagen and extracellular matrix, forms and creates new blood vessels through angiogenesis. These vessels supply oxygen and nutrients to fibro blasts, supporting tissue growth. Healthy granulation tissue appears pink and granular, indicating healing progress. Black or dark tissue may signal infection or poor blood flow. Epithelialization is crucial; it involves the emergence and growth of epithelial cells to cover the wound surface, forming new epithelial tissue [6].

**Re modeling phase**

The re modeling or maturation phase, the fourth stage of wound healing, involves the transformation of dermal tissues once the wound has closed. Fibroblasts play a crucial role, and a key change is the shift from collagen type III to type I, which offers more strength and stability. During this phase, blood vessels decrease, reducing cellular activity and aiding in scar tissue maturation, making the healed wound less visible [4,6].

**Scar formation**

The final phase of wound healing involves scar formation. This process results in the development of collagen fibres that bridge and provide structural support to the healed area, forming a scar. [4,7].

**Problems related to wound healing**

Various factors can negatively affect the wound healing process, leading to impaired healing. Chronic wounds exhibit specific biological markers, influenced by both local and systemic factors. Local factors include issues like tissue maceration, foreign bodies, bio film formation, hypoxia, ischemia, and wound infection. Systemic factors encompass conditions such as diabetes, advanced age, malnutrition, and chronic organ diseases. While adhering to good clinical practices, completely eliminating or reducing the impact of these factors is often challenging. Additionally, other factors like reduced tissue growth factors, elevated levels of proteolytic enzymes (e.g., matrix metallo proteinases degrading the extracellular matrix), increased inflammatory mediators (e.g., excessive





**Himangshu Deka et al.,**

neutrophil infiltration), and the presence of senescent cells can hinder healing and potentially serve as biomarkers for chronic wounds [8,9].

### **Poly herbal Cream**

A poly herbal cream is a topical formulation designed for external use on the skin. It combines multiple herbs, each with unique phyto constituents, to potentially enhance its effectiveness compared to individual extracts. Creating a stable poly herbal formulation can be challenging due to chemical incompatibilities from the various constituents. This study aims to develop and evaluate a stable poly herbal cream for effective wound healing [10]. The use of medicinal plants with antimicrobial, antioxidant, and anti-inflammatory properties has shown promise in aiding wound healing. Poly herbal formulations provide cost-effective treatment options, reducing therapy duration and the need for multiple medications to address inflammation and infections. With the increasing prevalence of infectious diseases and antibiotic resistance, delayed wound healing has become a concern. This study selected specific herbs to target various pathways involved in wound healing, including the reduction of inflammatory cytokines and signal cascades [11]. This study aims to investigate how specific herbs can reduce oxidative factors, enhance antioxidant enzymes, and inhibit microbial growth at wound sites. These herbs were chosen for their ability to target these critical mechanisms in wound healing. By reducing oxidative stress, boosting antioxidant enzymes, and preventing microbial growth, the poly herbal formulation may improve and speed up the healing process. In the current era, there's a need for wound healing formulations with antioxidant properties, recognizing the vital role antioxidants play in efficient wound healing. Developing products with antioxidants aims to address challenges associated with delayed wound healing and enhance overall healing. [11,12,13].

## **MATERIALS AND METHODS**

### **Collection and authentication of plant materials**

Fresh leaves of *Lawsonia inermis* and Piper betle were collected from the home garden in Sonkani village, located in the Nalbari district of Assam and the *Cynodon dactylon* plant was obtained from the roadside in Guwahati, Assam. The leaves underwent authentication at the Botanical Survey of India, Shillong, and they were assigned the following authentication numbers: BSI/ERC/Tech/2023-24/1073, BSI/ERC/Tech/2023-24/1074, and BSI/ERC/Tech/2023-24/1075, respectively.

### **Extraction of *Lawsonia inermis* L**

The plant materials were extracted using the maceration method with slight modifications. To prepare the extract, the dried leaves of *Lawsonia inermis* were finely ground into a powder using an electric grinder. A total of 50g of *L. inermis* powder was soaked in 200ml of water in a 500ml conical flask for 12 hours at room temperature. The contents of the flask were then filtered through four layers of muslin cloth. The filtrate was evaporated in a rotary evaporator at 50°C. The resulting extracts were further dried in a hot air oven at 50°C for 6 to 8 hours and finally stored at refrigerator until further use.

### **Extraction of *Piper betle* L**

The plant materials underwent extraction using the maceration method with slight modifications. For the extract preparation, the dried leaves of *Piper betle* were finely ground into a powder using an electric grinder. A total of 80g of *Piper betle* powder was soaked in 500ml of water in a 1000ml beaker for 12 hours at room temperature. The contents of the beaker were then filtered through four layers of muslin cloth. The filtrate was subjected to evaporation in a rotary evaporator at 50°C. The resulting extracts were subsequently dried in a hot air oven at 50°C for 6 to 8 hours and finally stored in a refrigerator until further use.

### **Extraction of *Cynodon dactylon***

The plant materials were extracted using the percolation method with slight modifications. To prepare the extract, the dried leaves of *Cynodon dactylon* were finely ground into a powder using an electric grinder. A total of 100g of



**Himangshu Deka et al.,**

*Cynodon dactylon* powder was soaked in 850ml of water in a 1000ml beaker for 12 hours at room temperature. The contents of the beaker were then filtered through four layers of muslin cloth. The filtrate was evaporated in a rotary evaporator at 50°C. The resulting extracts were further dried in a hot air oven at 50°C for 6 to 8 hours and finally stored in a refrigerator until further use [14].

**Phyto chemical screening**

In the present study, the extracts of *Lawsonia inermis*, *Piper betle*, and *Cynodon dactylon* were screened for various phyto chemicals, including alkaloids, carbohydrate, glycosides, saponins, steroids, and tannins.

**Formulation of poly herbal cream****Preparation of poly herbal cream**

A cream based on an oil-in-water emulsion was formulated by combining various ingredients in two separate phases. In Phase 1, stearic acid, liquid paraffin, glyceryl monostearate, and lanolin were dissolved in the oil phase and heated to a temperature of 75°C. In Phase 2, methyl paraben, glycerine, borax, isopropyl myristate, extracts of *Lawsonia inermis*, extract of *Piper betle*, and extract of *Cynodon dactylon* were dissolved in the aqueous phase and also heated to 75°C. Once both phases were heated, Phase 2 was slowly added to Phase 1 with continuous stirring until a homogeneous cream was formed [15].

**Evaluation of the cream**

There are multiple parameters available of evaluation of cream. The evaluation parameters used for this project work are physical evaluation (organoleptic evaluation, pH determination, viscosity determination) and pharmacological evaluation (in-vitro antioxidant test).

**Physical evaluation****Organoleptic evaluation**

The cream was evaluated based on its organoleptic properties, which include colour, odour, state and texture. The obtained results for each formulation are presented in Table No.2

**pH determination**

5 gm sample of the cream was accurately measured and placed in a 100ml beaker. 45ml of water was added to the beaker and the cream was dispersed within it. The pH of the resulting suspension was determined using a pH meter at a temperature of 27°C. The measured pH of the cream fell within the range of 6-7, which is considered favourable for maintaining the skin's pH balance. The obtained results for each formulation are presented in Table No.1

**Viscosity determination**

Viscosity measurements were performed using a Brookfield viscometer equipped with a S-64 spindle at a rotational speed of 100rpm and a temperature of 25°C. The obtained results for each formulation are presented in Table No.1

**Stability determination**

Thermal stability of the formulation was determined by the humidity chamber controlled at 60- 70% RH and 37 ± 1°C, relative humidity (RH). Result found of every formulation is specified in Table no.3

**Pharmacological evaluation****In-vitro Antioxidant test**

In vitro antioxidant activity by DPPH assay is a widely employed method for assessing the antioxidant potential of natural products. The following method is typically followed when conducting the DPPH assay. To assess the antioxidant potential of natural products using the DPPH assay, the following method was employed: A 0.1 mM DPPH solution was prepared in methanol, resulting in a purple/violet-coloured solution. The preparation involved dissolving 39.4 mg of DPPH in 1000 ml of solvent. Different concentrations of cream formulation (e.g., 10, 20, 40, 80, 160, 320 µg/ml) were prepared by dissolving the extracts in a suitable solvent like methanol. In each trial, 3 ml of the

70629





Himangshu Deka et al.,

DPPH solution was mixed with different concentrations of the cream formulation. A standard solution of ascorbic acid was also prepared. Each sample and standard were prepared in triplicate. The samples were then placed in a dark environment and incubated for 30 minutes. Following the incubation period, the absorbance of each sample was measured at 517 nm using a UV spectro photometer. This entire experiment was repeated three times for each concentration, and the average absorbance value was recorded [16]. The DPPH inhibition percentage was calculated for each plant extract concentration using the formula:

$$\text{Percent inhibition of DPPH} = \frac{(\text{Control absorbance} - \text{Sample absorbance})}{\text{Control absorbance}} \times 100$$

The obtained results for each formulation are presented in Table No.4 and curves are shown in figure no.2,3,4 and 5.

## RESULTS AND DISCUSSION

In this section, we present a compilation of the results obtained from various conducted investigations.

### Phyto chemical Analysis

A phyto chemical analysis of *Lawsonia inermis*, *Piper betle*, and *Cynodon dactylon* indicated the presence of alkaloids, carbohydrates, tannins, steroids, saponins, and phenolic compounds.

## CONCLUSION

In conclusion, the development and evaluation of a poly herbal cream possessing antioxidant properties that aid in the healing of wounds has shown promising results. The study aimed to explore the potential of natural herbal extracts in promoting wound healing by harnessing their antioxidant properties. Throughout the research process, various herbal ingredients (*Lawsonia inermis* L., *Piper betle* L., and *Cynodon dactylon*) known for their wound healing properties were carefully selected and combined to create a poly herbal cream. The cream was formulated with the intention of enhancing the wound healing process. The evaluation of the poly herbal cream involved in vitro study, which provided valuable insights into its effectiveness. In vitro experiments demonstrated the antioxidant capacity of the cream by measuring its ability to scavenge free radicals.

## ACKNOWLEDGEMENT

We convey our special acknowledgment to Assam down town University, for providing facilities.

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## Himangshu Deka et al.,

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Table 1: Formulation table

Sl no.	Ingredients	Formulation1	Formulation2	Formulation3
1	<i>Lawsonia inermis</i> extract (API)	4.8ml	1.6ml	3.2ml
2	<i>Piper betle</i> extract (API)	3.2ml	4.8ml	1.6ml
3	<i>Cynodon dactylon</i> extract (API)	1.6ml	3.2ml	4.8ml
4	Liquid paraffin	2.66ml	2.66ml	2.66ml
5	Stearic acid	1.33gm	1.33gm	1.33gm
6	Glyceryl monostearate	1gm	1gm	1gm
7	Lanolin	0.33gm	0.33gm	0.33gm
8	Glycerine	2.66ml	2.66ml	2.66ml
9	Borax	0.26gm	0.26gm	0.26gm
10	Methyl paraben	0.02gm	0.02gm	0.02gm
11	Isopropyl myristate	0.66ml	0.66ml	0.66ml
12	Water	10ml	10ml	10ml

Table no.2: Result of physical evaluation

Sl no.	Test	F1	F2	F3
1	PH	6.5	6.7	6.6
2	Viscosity	2862cP	2856cP	2868cP





Himangshu Deka et al.,

**Table no.3: Result of organoleptic properties**

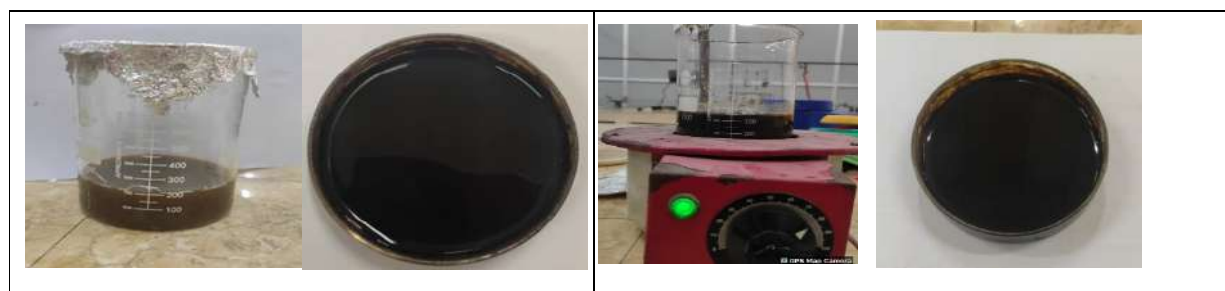
Sl no.	Specification	F1	F2	F3
1	Colour	Light brown	Creamy brown	Light brown
2	Odour	Characteristics	Characteristics	Characteristics
3	State	Semi solid	Semi solid	Semi solid
4	Texture	Smooth	Smooth	Smooth

**Table no.4: Result of thermal stability test**

Test	F1	F2	F3
Thermal stability (at RH 65% and 30°C)	Stable, no oil separation	Stable, no oil separation	Stable, no oil separation

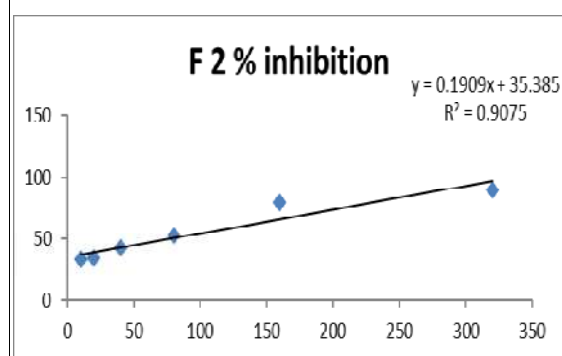
**Table no.5: Calculation of Antioxidant activity of the sample (F1, F2, F3) with DPPH**

Sl no.	Concentration	Std.% Inhibition	F1% Inhibition	F2% Inhibition	F3% Inhibition
1	10	38.84514436	16.27296588	33.85826772	12.59843
2	20	46.9816273	37.00787402	34.3832021	26.50919
3	40	57.48031496	52.49343832	42.78215223	48.55643
4	80	63.51706037	62.72965879	52.49343832	56.95538
5	160	83.20209974	79.00262467	79.26509186	71.91601
6	320	97.37532808	89.50131234	89.76377953	84.25197



**Figure 1: Extraction of Lawsonia inermis**

**Figure 2: Extraction of Piper betle Extract**



**Figure no.3: F2% Inhibition of Antioxidant analysis**



**Figure 4: Formulation of Polyherbal Cream**





Himangshu Deka et al.,

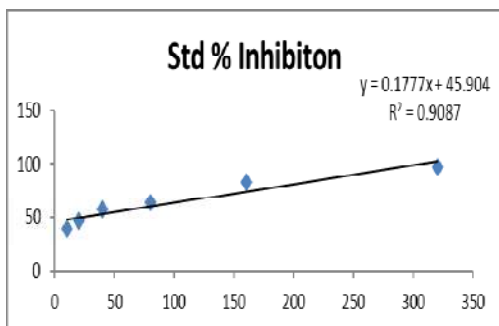


Figure 5: Std% inhibition of Antioxidant analysis

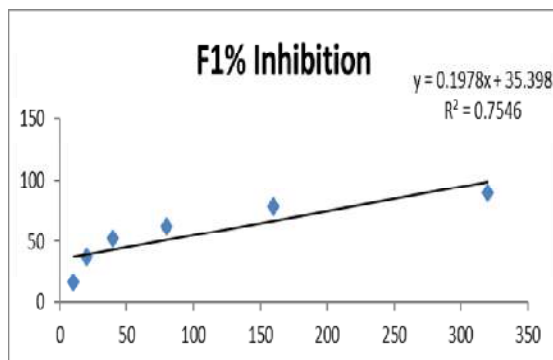


Figure 6: F1% inhibition of Antioxidant analysis

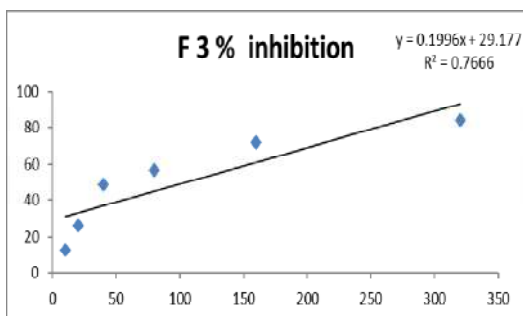


Figure 7: F3 % Inhibition of Antioxidant analysis







## Comparative Study of Bio Plastic Production from Plants

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### ABSTRACT

Plastics are made of fossil fuel resources and are widely used in packaging for their easiness and disposability which ultimately leads to contamination. Bio plastic being bio based and degradable is used as a replacement for plastic to reduce their harmful effects. For production of bio plastic organic wastes can be used as biomass, thus aids in reduction of fossil fuel consumption. This project chiefly intended to develop bio plastic sheets from organic plant wastes such as Banana Spathe, Money plant Leaves and Watermelon Rind with Poly vinyl alcohol and compared for efficiency. The thin, flexible, semi-transparent bio plastics sheets obtained were taken for different analysis tests such as thickness, solubility test, flammability test, biodegradability test, FTIR, tensile strength. The resultant bio plastic sheets had adequate thickness and other characteristics besides it was completely degraded within 45 days. By the current study, we can conclude that the samples have complete potential to utilize for bio plastic production.

**Keywords:** Banana spathe, Biodegradable, Bioplastics, Money plant, PVA, Watermelon rind

### INTRODUCTION

Plastics made of Polypropylene, polyethylene, polystyrene, and polyethylene are frequently used mostly as single use packaging material [1]. These are primarily developed from fossil feedstock which accounts for nearly 4-8% worldwide consumption of oil [2]. Most of the packaging materials are disposed of after single use instead of





Narmatha et al.,

recycling which ultimately end up in landfills and cause serious damage to the environment [3]. Land filled plastic causes serious effects to the environment by leakage of lethal chemicals, plastic fragments and micro plastics that have had an alarming effect on coral reefs, marine mammals along with terrestrial life [2]. Hence, Conventional plastics unveil countless effects on the planet by non-biodegradability, defying recyclability as well as being pollutant to the ecosystem [4]. Hence, it is necessary to consider before using such types of materials, it is essential to protect Mother Nature. There is a need to find a solution for this field since the strategies for the plastic waste management is not helpful as the recycling does not reach the target and incineration is more harmful than helpful. The key to this dilemma is either a new approach to waste management or alternative to petroleum-based plastic.

Bio plastic can be defined as the plastic which are made of renewable biomass such as organic wastes, starch of potato and corn etc., along with the help of plasticizers (for example: glycerol, citric acid, etc.,) and they may be biodegradable or non-biodegradable. Biodegradable plastic can substitute ordinary plastic at very low cost and once it is disposed of it can be easily decomposed by the activity of microorganisms such as composting within a short span of time. This study is an attempt to utilise bio waste such as Watermelon Rind, Banana spathe and Money plant leaf as a plant source polymer to produce bio plastic with PVA which is a synthetic polymer also non-toxic, odour less and biodegradable. Watermelon is a climber and originated from tropical Africa. It is botanically called *Citrullus lanatus*. It is a summer season fruit which appears as spherical, oblong in shape and the inner edible flesh is sweet and pink or yellow in colour. Their rinds show green and black strips or black, green alone without strips. The seeds are mostly black in colour and the seeds are edible in some countries like India and China. The fruit is a summer delicacy. The rind of this fruit is mostly thrown as a waste which is utilised for bio plastic as natural polymer in this study. Money plant is botanically called as *Epipremnum aureum* and also has a synonym *Scindapsus aureus*. Money plant is native to New Guinea and South eastern Asia. It grows in soil and in water. It is mainly used as an ornamental plant and as an indoor plant. As this plant is propagated easily by cuttings and is a fast-growing plant with no commercial utilization of the plant parts, the leaves can be used for the preparation of bio plastics. Banana spathe is the protective covering for the flowers of bananas. It is botanically called *Musa paradisiaca*. It is an herbaceous plant with a tree-like pseudo stem. The pseudo stem of banana is a waste product in Bangladesh and they use it for making fibre to make yarn and as fertilizers, handicrafts, paper etc. The flowers of banana are also used in cooking as it has many medicinal properties. The banana spathe is thrown as waste, so this can be utilised for the preparation of bio plastics.

## MATERIALS AND METHODS

### Sample Collection

Watermelon (*Citrullus lanatus*) rinds as waste are collected from nearby local market of New Washermenpet, Money plant (*Epipremnum aureum*) leaves are collected from home garden in Chennai, Banana (*Musa paradisiaca*) flower was bought in the local market and the spathe as waste is used.

### Preparation of Extract

The collected samples were washed in running tap water and distilled water. The sample is cut into small pieces and soaked in sodium bicarbonate solution for some time. Then the small pieces are boiled in water and the water is decanted. The cooked pieces are grinded into fine paste using a blender and the paste is filtered using filter paper into a beaker.

### Bio plastic Preparation

To the extract, Poly Vinyl Alcohol (PVA), citric acid and glycerol is added in a beaker. The mixture was kept on a magnetic stirrer with RPM (500 – 600) with minimum temperature. It was spread on glass plates and dried at room temperature for 12 hours. The sheet was peeled off from the glass plate carefully. The obtained Bio plastics were taken for further analysis.





Narmatha et al.,

**Analysis of Bio plastics****Morphological Analysis**

The obtained bio plastic sheets of different samples were analysed for its flexibility, colour, texture as well as brittleness and compared.

**Measurement of Bio plastic Thickness**

The thickness of the bio plastic sheets of different samples was measured with a screw gauge and compared.

**Determination of Water Absorption [8,9]**

Bio plastic sheet of each sample was taken as 2cm × 2cm strips and weighted, further placed in a Petri plate containing distilled water for 24 hours after which the strips were removed from the water and weighed again. The water absorption was calculated using the formula.

$$\text{Water absorption\%} = \frac{W_t - W_o}{W_o} \times 100$$

Where,  $W_t$  = Weight of the sample after absorption,  
 $W_o$  = Weight of the sample before absorption

**Determination of Melting Point [5,6]**

Bio plastic of each sample as strips were placed into the test tubes which were immersed in a beaker containing water. The beaker with water was heated. The temperature of water in the beaker was monitored continuously with a thermometer along with the changes in the bio plastic strips. The temperature at which the strips start to melt was noted and compared.

**Flammability Test [7]**

Bio plastic sheets of each sample were taken as strips which were held in a vertical position with the help of forceps by exposing the lower end of the strip to flame for some time. The flammability was determined by the ability of the strips to burn even after removing from the flame and time taken for the flame to reach the other end was noted. Dripping of the sheets due to melting was also observed.

**Solubility Test [8]**

The bio plastic of each sample was taken as strips. They were dipped into test tubes containing 3ml of different solvents such as acetone, ethanol, chloroform, sulphuric acid, butanol, acetic acid, ammonia, sodium hydroxide, petroleum ether, benzene, hydrochloric acid and water. After 1 hour, the solubility of the samples was observed and the results were tabulated.

**Shelf-Life Testing [9]**

It was performed to determine the durability level by taking strips of each sample sheet followed by placing it in an airtight container and another set exposed open at room temperature for 30 days. Afterwards, strips were analysed through visual observations for attack of microorganisms, change in colour and texture.

**Determination of Weight Loss Percentage**

It was determined by taking the initial and final weight of strips of each sample sheet, which was kept in an air tight container and another set in open at room temperature for 30 days. The weight loss percentage is calculated using the formula

$$\text{Weight loss\%} = \frac{W_i - W_f}{W_i} \times 100$$

Where,  $W_i$  – initial weight of the sample,  
 $W_f$  – Final weight of the sample



Narmatha *et al.*,**Bio degradability Test [6,9]**

Bio degradability behaviour of bio plastic sheet of each sample was carried out by soil burial degradation method where 5cm × 5cm strip of each samples initial weight was noted then placed in beakers filled with soil at depth of 2cm from the surface. Every 5 days the strips were taken out and weighed to determine the loss of weight. The test was carried out for a period of 30 days. Then the percentage of biodegradation was calculated for each sample.

**Fourier Transform Infrared Spectroscopy (FTIR) Analysis [5,6,8]**

Bio plastics of all 3 samples were observed under domain spectra of 4000 cm<sup>-1</sup> to 400 cm<sup>-1</sup> frequency to examine its interaction and chemical bonding between PVA and samples respectively.

**Determination of Tensile Strength by UTM [10]**

The bio plastic sheet of each sample was taken into strips of 150mm × 25mm to determine tensile strength by ASTM D 882 method. Average of 4 strips for each sample were taken for analysis in CIPET- Chennai.

**RESULTS AND DISCUSSION****Morphological Analysis**

The bio plastic obtained from watermelon fruit rind was light green in colour, semi-transparent, flexible, smooth in texture, glossy on one side and not brittle. The bio plastic obtained from the money plant leaf was green in colour, semi-transparent, flexible, smooth in texture and not brittle. The bio plastic sheet obtained from banana spathe was brown in colour, semi-transparent, flexible, smooth in texture and not brittle. (Figure no: 1)

**Measurement of Bioplastic Thickness**

The bio plastic obtained from watermelon fruit rind has an average thickness of  $0.086 \times 10^{-3}$  m (86 microns). The bio plastic obtained from money plant leaves has an average thickness of  $0.088 \times 10^{-3}$  m (88 microns). The bio plastic obtained from banana spathe has an average thickness of  $0.136 \times 10^{-3}$  m (136 microns) Table 1. According to recent plastic waste management amendment rules, 2021, in Rule no. 3; it is said that the thickness of the plastic carry bags should be in the range of 75 to 120 micron from 30th of September 2021 [11]. Thus, the result indicated that the prepared bio plastic of Watermelon fruit rind has a thickness of 86 micron. Hence, the results prove that these samples have the potential of preparing packaging material and carrying bags.

**Determination of Water Absorption**

The water absorption percentage of Watermelon rind bio plastic is 12.5%, Money plant leaf is 28% and Banana spathe is 21% (Table 2). A study by Rahmatiah and Kang (2016) proved that water absorption of bio plastic increased with increased starch content. In the present study money plant leaves absorb more water and this explains that it had a higher amount of starch [12].

**Determination of Melting Point**

The watermelon fruit rind bio plastic began to melt at temperature of 98°C, whereas money plant leaf began to melt at 88°C and banana spathe began to melt at 96°C. With an increase in temperature, the starch vibrates more vigorously thus breaking the starch – plasticizer interactions and begins to melt [5].

**Flammability Test [15]**

The time taken for the flame to reach the other end of the strip was 40 seconds for Watermelon fruit rind bio plastic. For money plant leaf bio plastic, it was observed to be 38 seconds and in banana spathe bio plastic it was observed to be 42 seconds. In all the 3 bio plastics, no dripping of the sample was observed instead they burnt completely resulting in ashes. The results were slightly different from the results obtained by A Muhammad *et al.*, [13] done using soybeans waste, the flame was yellowish-orange in colour and released some sparks when ignited.





Narmatha et al.,

### Solubility Test

The solubility test performed with watermelon rind bio plastic, money plant leaf and banana spathe bio plastic showed that the strips are insoluble in some solvents and completely soluble in some whereas partly dissolved and swells in some solvents (Table: 3). Vimolvan Pimpan et al., [8] in his study showed acidic solutions and pure water can make the samples swell but water can dissolve the samples at elevated temperature.

### Shelf-Life Testing

The 3 different bio plastics sheets were kept in an air tight container and also kept open in room temperature were observed after 10 days. There were no visible changes in the colour, flexibility, texture and also there was no attack by microorganisms. A high concentration of glycerol serves as an antifungal which can control the growth of fungi for bio plastic, thus offering an increased shelf life [14].

### Determination of Weight Loss Percentage

The weight loss percentage of watermelon rind bio plastic in room temperature is 2.05% and in air tight condition is 1.08%. The weight loss percentage of money plant leaf bio plastic in room temperature is 5.5% and in airtight condition is 4.3%, whereas no weight loss was observed in banana spathe bio plastic in room temperature and in airtight condition (Table 4).

### Biodegradability Test

The percentage of biodegradation rate of Watermelon rind is 7.21%, for Money plant leaf is 15.4% and for Banana spathe bio plastic is 14.89% (Table 5). Nanang et al.,[9] concluded, High concentration of glycerol contained in bio plastics led to rapid mass reduction. The hydrophilic nature caused bio plastics to be degraded more easily, making bio plastics an eco-friendly packaging material. The degradation process of bio plastics was done with the help of microorganisms such as bacteria and fungi, mechanical degradation (wind and abrasion), and light (photo degradation).

### FTIR Analysis

The result obtained from the FTIR analysis of watermelon rind, Money plant leaf and Banana spathe bio plastic displayed peaks at 3279.46, 2922.60, 1088.37 wavelength  $\text{cm}^{-1}$  which represents stretching O-H symmetric, Methylene C-H stretch and organic silicone or siloxane respectively (graph: 1, 2, 3).

### Determination of Tensile Strength by UTM

Tensile strength of the watermelon rind bio plastic was determined as 81.0 Mpa and elongation at break was 14.7% by means of ASTM D 882. Tensile strength of Money plant leaf bio plastic was determined to be 151.1Mpa and elongation at break was 20.3%. Tensile strength of Banana spathe was determined to be 238.6 Mpa and elongation at break was 19.5%. Comparing all the 3 samples Banana spathe bio plastic had more tensile strength and elongation at break. Further research work has to be made to standardize the composition of these bio-based plastics as they have potential to be an alternative to regular plastic.

## CONCLUSION

Conventional plastics having a disadvantage such as non-degradability, increased solid waste, usage of fossil fuels as source, increased CO<sub>2</sub> footprint, contamination underground soil and water system, blocking drainage system owing to unethical disposal of single use plastics which leads to the ocean and corrupt the marine ecosystem, even the waste management of plastic causes more pollution to environment. Hence in the current study, Watermelon rinds were used as natural polymers to reduce waste and for efficient utilisation of waste for preparation of bio plastic. On obtained bio plastic sheets, the watermelon rind shows slightly higher integrity and stability, more tensile strength, thickness and flexibility. This study shows the complete potential of these waste materials to be an integral bio



**Narmatha et al.,**

plastic as they are cost effective, act as nutrient for plants after degradation in the soil and are environmentally friendly.

### FUTURE SCOPE

Further study is required to stabilize both the samples bio plastic potential in order to acquire hydrophobicity, stability and sturdiness for better ecosystem, wellbeing and to protect mother earth.

### CONFLICT OF INTEREST

Authors have declared that no competing interests exist.

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### Contribution

Both the authors contributed equally to this work.

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**Table 1: Thickness of the Bio plastics**

S.NO	SOURCE OF BIOPLASTIC	THICKNESS IN MICRON
1.	<i>Epipremnum aureum</i> leaves	0.088×10 <sup>-3</sup> m
2.	<i>Musa paradisiaca</i> spathe	0.136×10 <sup>-3</sup> m
3.	Watermelon rind	0.086 × 10 <sup>-3</sup> m

**Table 2: Table for Determination of Water Absorption**

SOURCE OF BIOPLASTIC	INITIAL WEIGHT (g)	FINAL WEIGHT (g)	WATER ABSORPTION
<i>Epipremnum aureum</i> leaves	0.25	0.32	28%
<i>Musa paradisiaca</i> spathe	0.37	0.45	21%
Watermelon rind	0.40	0.45	12.5%

**Table 3: Solubility Test of the bio plastics respectively**

SOLVENT USED	<i>Epipremnum aureum</i> LEAVES BIOPLASTIC			<i>Musa paradisiaca</i> SPATHE BIOPLASTIC			WATERMELON RIND BIOPLASTIC		
	Soluble	Partially soluble	Not soluble	Soluble	Partially soluble	Not soluble	Soluble	Partially soluble	Not soluble
Water	-	+	-	-	+	-	-	+	-
Acetone	-	-	+	-	-	+	-	-	+
Ethanol	-	-	+	-	-	+	-	-	+
Chloroform	-	-	+	-	-	+	-	-	+
Sulphuric acid	-	+	-	-	+	-	-	+	-
Butanol	-	-	+	-	-	+	-	-	+
Acetic acid	-	-	+	-	-	+	-	-	+
Ammonia	-	+	-	-	-	+	-	+	-
Sodium hydroxide	-	+	-	-	-	+	-	+	-





**Narmatha et al.,**

Petroleum ether	-	-	+	-	-	+	-	-	+
Benzene	-	-	+	-	-	+	-	-	+
Hydrochloric acid	-	+	-	-	-	+	-	+	-

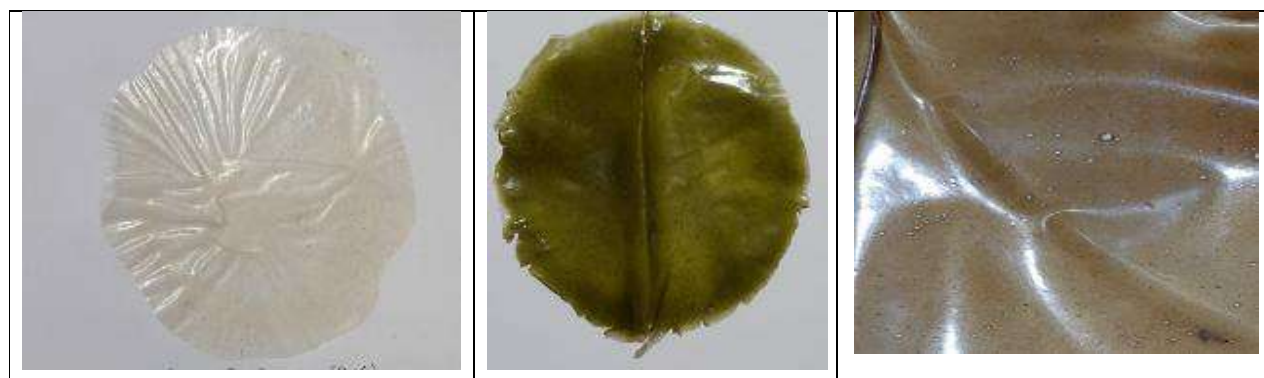
\*+ positive result, - negative result

**Table 4: Determination of weight loss percentage**

S.NO	SAMPLE	Bio plastics kept open in room temperature			Bio plastics kept inside an air tight container		
		Initial weight (g)	Final weight (g)	Weight loss%	Initial weight (g)	Final weight (g)	Weight loss%
1.	<i>Epipremnum aureum</i> leaves	0.18	0.17	5.5	0.23	0.23	4.3
2.	<i>Musa paradisiaca</i> spathe	0.25	0.25	0	0.28	0.28	0
3.	Watermelon rind	0.80	0.78	2.5	0.92	0.91	1.08

**Table 5: Biodegradability Test**

S.NO	NUMBER OF DAYS	WEIGHT OF THE SAMPLE (g)		
		<i>Epipremnum aureum</i> leaves bio plastic	<i>Musa paradisiaca</i> spathe bio plastic	Watermelon fruit rind bio plastic
1	1 <sup>st</sup> day	0.97	0.94	0.97
2	5 <sup>th</sup> day	0.95	0.91	0.94
3	10 <sup>th</sup> day	0.82	0.80	0.90

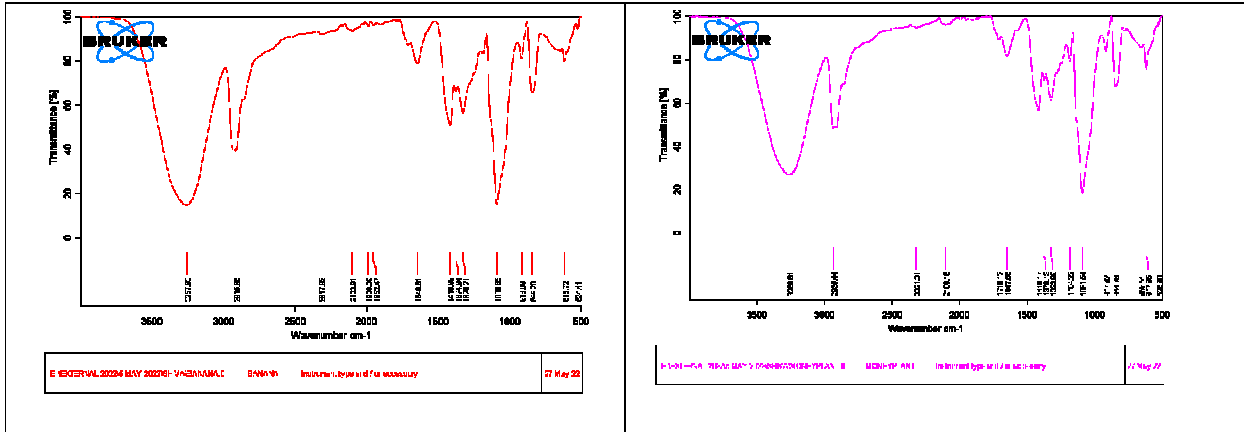


**Figure no 1: Image shows the bio plastic sheets made from Watermelon rind, Money plant leaves, and Banana spathe respectively**



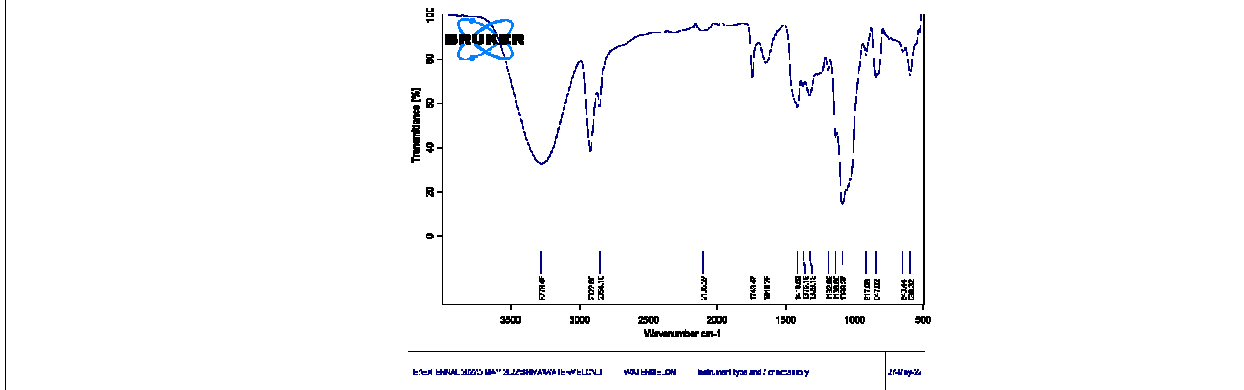


Narmatha et al.,



Graph 1: FTIR – Banana spathe bioplastic

Graph 2: FTIR - Money plant leaf bioplastic



Graph 3: FTIR - Watermelon rind bioplastic





## Relation of Flat foot with Knee Osteoarthritis in Adults

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### ABSTRACT

Knee OA, a common type of arthritis, is a leading cause of knee pain and disability. Most of the research has focused on local knee malalignment. However, the foot plays a more immediate role in absorbing the mechanical stresses from ground and may influence the knee loading during walking. Aim was to assess the relationship of flat foot with knee osteoarthritis in adults. Cross sectional study conducted at Dhiraj General Hospital, Vadodara. Diagnosed cases of knee OA of both genders greater than 40 years were included. Detailed clinical assessment, WOMAC and footprint of both feet of all patients were taken. Presence of flat foot was determined by Staheli's Arch Index (SAI) index. Relation of flat foot with OA knee was determined by odds ratios with 95% CI. Correlation between WOMAC and SAI was assessed using Pearson's correlation coefficient. Total 73 patients (26 Males, 47 Females) with knee OA participated in the study with mean age of 54.66±8.48 years. Compared with all other feet, flat foot had 1.08 and 1.26 times the odds of Osteoarthritis of knee on left and right side respectively. There was no statistically significant correlation between WOMAC and SAI. Knee OA patients are more prone to have flat foot but disability caused by knee OA is not related to flat foot.

**Keywords:** Knee OA, flat foot, foot posture, SAI While assessing a patient with knee OA, the patient's foot posture should also be taken into consideration and appropriate measures undertaken to correct the foot posture.



**Dhvani P Naik and Neha Mukkamala**

## INTRODUCTION

Knee osteoarthritis (OA) which is the most common type of arthritis, is the leading cause of knee pain and disability. [1] Estimates suggest that 3.8% of the world's population suffer from symptomatic knee OA. [1] The prevalence of knee OA in rural and urban India is estimated to be 3.9% and 5.5%, respectively. [1] The risk factors of knee OA can be divided into systemic like age, gender, genetics, and overweight and local biomechanical factors, such as joint injury malalignment, overweight, and muscle weakness. [2,3,4,5,6,7] Many of the characteristic features of knee OA are related to mechanical loading and majority of research has focused on the consequences of local knee malalignment. However, the foot plays an even more immediate role in absorbing the mechanical stresses from ground. [8] The foot position and motion may influence the knee loading during walking as it is biomechanically linked to the knee within a closed kinetic chain. [9] The risk of tissue damage or frequent knee symptoms due to abnormal foot posture is little known, despite the foot having a central role in lower extremity biomechanics. [8] Studies suggest that people with knee OA are known to possess a more flat foot type compared to controls. [8, 10] Furthermore, Guler et al. showed that the disability level in women increases with coexisting foot deformities, including flat foot. [9,11] Interventions using foot orthosis that aim to reduce knee loading and knee pain have also been reported. [8, 9, 10,12,13] If a relation between flat foot and knee OA is found it will help in planning treatment to alter foot posture via appropriate foot orthosis/arch supports and exercises directed at the foot, and might serve to reduce the risk of symptomatic OA in targeted knee compartments. So, this study was undertaken to see relation of flat foot with knee osteoarthritis in adults.

## METHODOLOGY

This cross sectional study was conducted in Dhiraj General Hospital, vadodara. We included male and female patients diagnosed with knee OA above the age of 40 years. Individuals with history of knee surgery, inflammatory arthritis in lower limb joints, presence of neurological problems, recent trauma or fractures in lower limb and any congenital deformity in lower limb were excluded. Approval was obtained from Institutional Ethics Committee. The trial was also registered with clinical trial registry of India (CTRI/2019/09/021355). An informed consent form was also taken from all patients. Detailed clinical examination of each patient was done. In addition western Ontario and McMaster Universities Arthritis Index (WOMAC) was taken. The footprint of each patient was taken as follows Patient's footprint was taken on a stamp pad (dimensions:-length 47 cm and width 31.5 cm). The patient was asked to stand erect barefoot. He/She was asked to take a step on the stamp pad alternately with both the legs, and then alternately step on the plain piece of paper kept in front of stamp pad. The patient was given the choice of stepping with the leg of his/her preference. Staheli Arch Index (SAI) index was calculated on the paper as follows The length of each footprint was taken from the most distal extent of the forefoot (toes excluded) to the most proximal extent of the heel and was divided into thirds in order to define the rear foot(heel), mid foot(arch), and forefoot regions. The SAI is defined as "the ratio of the smallest medial to lateral width of the arch region divided by the greatest medial to lateral width of the heel region". [8] One reading was taken for both the feet. If SAI is 0.57 to 1.20 then it is considered as flat feet and if SAI <0.57 then it considered as other foot. If SAI is '0' it is considered as cavus foot. [8]

## STATISTICAL ANALYSIS

Data were expressed as the mean  $\pm$  standard deviation for nominal variables [i.e. age, weight, Body mass index (BMI), WOMAC score, duration of symptoms, Q angle] and as median for ordinal variables (i.e. SAI index). The normal distribution was assessed by kolmogrov smirnov Test. Correlations among BMI and SAI, WOMAC and SAI, BMI and WOMAC were assessed by using Pearson's correlation coefficient. Statistical significance was set at  $p < 0.05$ . Relation of flat foot with OA knee was presented as proportional odds ratios (ORs) with 95% CI.



**Dhvani P Naik and Neha Mukkamala**

## RESULTS

Total seventy three patients were included in the study. Table 1 shows characteristics of the population. There were 26 males (35.61%) and 47 females (64.38%). Age ranged from 40 years- 75 years. In the present study, 41% of patients were obese, 38% were normal weight and 19% were overweight. There were 58 (79.45%) patients with bilateral OA and 15 (20.54%) with unilateral OA. Table 2 shows the mean values of Q angle in females and males. Females had a higher Q angle than males. Table 3 shows SAI score of the population. Flat foot was found in 53% patients on right side and 52% on left side. Also bilateral flat foot was found in 42% patients and unilateral flat foot in 20%. Compared with all other feet, flat foot had 1.08 and 1.26 times the odds of osteoarthritis of knee on Left and Right side respectively in our study. Table 4 shows correlation of BMI, WOMAC and SAI. There was a statistically significant ( $p < 0.05$ ) positive correlation between BMI and SAI index. Tables 5 and 6 show association of Kellgren Lawrence grading with SAI for left and right sides respectively.

## DISCUSSION

The present study was undertaken to see relation of flat foot with knee osteoarthritis in adults. Age which is most significant risk factor of Osteoarthritis knee [2, 3, 4, 5] ranged from 40 years- 75 years. Degradation and loss of Particular cartilage which is a central feature in OA knee is due to joint aging and repeated "wear and tear". [4, 5] The mean duration of symptoms of our population was 32.36+38.12 months, which indicates the chronicity of the disease. [3] The number of females in the present study was more than males, which is in agreement with literature that females are more prone to (11.4% vs 6.8%) having osteoarthritis of knee than males. [2,3,6,7] One of the reasons for this is anatomic differences like narrower femurs, thinner patellae, larger quadriceps angles, differences in tibial condylar size and knee cartilage volume. [6] Also, postmenopausal women, are at an increased risk of developing arthritis which has been linked to the decrease in estrogen during this time. [6,7] In present study 41% of patients were obese, 38% were normal weight and 19% were overweight. Obesity causes increased mechanical loading of the knee and hip, which leads to cartilage damage in weight-bearing joints. In addition to mechanical, metabolic factors also play a role in OA, by altering the articular cartilage metabolism. It has been hypothesized that leptin system could be a link between metabolic abnormalities in obesity and increased risk of OA. [2,3]

Females in present study had a greater Q angle than males, which is due to wider pelvis in females, as it is necessary for femur to come inward to increased angle to make distal end of the femoral condyles parallel to ground. [14, 15] The Q angle was found to be more than normal in our population. An increased Q-angle results from malalignments of the lower limbs, like valgus knees, and alters the pressure distribution over the medial and lateral compartments of the joint. Probably biomechanical factor contributes to Particular cartilage wear and the initiation of knee OA. [16] In a study the patella femoral contact pressures increased over the lateral facet of the patella in knees having Q angle greater than 10 degrees normal in 50% of the population. [16]. In the present study the number of patients with bilateral OA were more compared to unilateral OA. Bilateral knee osteoarthritis is very common with time and eventually majority patients will develop radiographic disease in both knees. So clinicians and researchers should account for both knees while assessing for unilateral disease. [17]. Flat foot was found in 53% patients on right side and 52% on left side. Also bilateral flat foot was found in 42% patients and unilateral flat foot in 20%.

Compared with all other feet, flat foot had 1.08 and 1.26 times the odds of osteoarthritis of knee on Left and Right side respectively in our study. Loss of medial Tibio femoral joint space in knee OA leads to varus knee malalignment, to allow full plantar contact of weight bearing foot with the ground, this creates a demand for foot flattening is created. [8, 18, 19] This can cause the ground reaction force vector to pass more medial to the knee joint center during gait, resulting in increased loads across the medial compartment, which is indicated by the external knee adduction moment. Consequently it leads to increased foot pronation by shifting the centre of pressure laterally, to reduce the load on the medial compartment. [10,11,20] Excessive flattening of the weight-bearing foot can





**Dhvani P Naik and Neha Mukkamala**

bring about increased rotational stress on the load-bearing tissues of the Tibiofemoral joint causing transverse plane rotation to occur in the medial compartment of the Tibiofemoral joint. [8] Also studies have shown that people with knee OA have a more flat foot compared to asymptomatic controls. [10,11,21]. Knee Osteoarthritis causes the patient to become functionally more disabled which we assessed by WOMAC questionnaire. [2,22] The mean WOMAC score of our population was 32.73±9.39, which indicates mild to moderate disability in our patients also the mean score of pain, stiffness and physical function was 7.15, 2.29, and 23.29, which indicates pain and physical function was more disabling for patients compared to stiffness. There was no statistically significant correlation between SAI and WOMAC. Hirota et al (2017) [9] found that physical performance was similar between patients with and without bilateral flat feet, and also bilateral, not unilateral flat feet are associated with worse knee pain and disability. In our study also we found more patients with bilateral flat foot than unilateral flat foot. There was a fair positive correlation found between BMI and SAI, which indicates obesity as a risk factor to having more pronated foot, also noted by different studies in various population. [23, 24, 25, 26] There are some limitations of this study. First due to cross-sectional design of the study causal relation between knee osteoarthritis and flat foot cannot be established. Second, present study sample size is low which limits its ability to generalize our results to other population and it may reduce the statistical power of the study, so we recommend further study with larger sample size to make the results of this study more applicable. Further the effect of the contra lateral knee was not analysed. Patients with bilateral knee osteoarthritis have not been taken separately from unilateral knee osteoarthritis. In conclusion, we found that compared with all other feet, flat foot had 1.08 and 1.26 times the odds of knee osteoarthritis on left and right side respectively. There was no statistically significant correlation found between WOMAC and SAI.

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**Dhvani P Naik and Neha Mukkamala**

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**Table 1. Characteristics of study population**

Variable	Mean	SD
Age(years)	54.66	8.48
Weight(kg)	67.77	12.85
BMI(kg/m <sup>2</sup> )	26.9	5.09
WOMAC score	32.73	9.39
Duration of symptoms(In months)	32.36	38.12

**Table 2. Mean Qangle of population**

Variable	mean	SD
Qangle Right male	15.88	4.43
Qangle Left male	15.92	4.04
Qangle Right female	19.02	4.14
Qangle Left female	17.38	4.43





**Dhvani P Naik and Neha Mukkamala**

**Table 3 shows SAI score of the population.**

Variable	Median	IQR
SAI Right	0.57	0.44-0.65
SAI Left	0.58	0.47-0.67

**Table 4 shows correlation of BMI, WOMAC and SAI.**

Variables	r value	p value
BMI with SAI Right	0.24	0.041
BMI with SAI Left	0.27	0.022
WOMAC with SAI Right	0.08	0.49
WOMAC with SAI Left	0.08	0.5
BMI with WOMAC	0.21	0.071

**Table 5. Association of KL grading with SAI for Left Side**

KL Left	SAI Left		Total	Chi square =2.44, p value =0.65
	Flat foot	Other feet		
Noxray	7	10	17	
I	6	3	9	
II	7	7	14	
III	15	14	29	
IV	3	1	4	
Total	38	35	73	

**Table 6:- Association of KL grading with SAI for Right side**

KL Right	SAI Right		Total	Chi square =0.85, p value =0.93
	Flat foot	Other feet		
Noxray	9	8	17	
I	4	4	8	
II	14	9	23	
III	10	11	21	
IV	2	2	4	
Total	39	34	73	





## Effect of Phosphate Solubilizing Bacteria on the Growth of *Solanum lycopersicum* L.

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### ABSTRACT

Phosphorus is one of the vital micronutrients for plant growth, most of which remains insoluble in the soil. In this study, phosphate-solubilizing bacteria were obtained from the roots of the tomato (*Solanum lycopersicum*) plant, and Pikovskaya's medium was used for isolation based upon the dissolved phosphorus halo. The isolate that produced halo zones was analyzed further by gram staining and, then the broth medium inoculated with different concentrations (total 11 concentration) bacteria was prepared. Twenty-four plants of tomato (*Solanum lycopersicum* var. pusa ruby) that were planted in pots were then treated with the prepared broth and, for each treatment; two plants were taken to evaluate their beneficial effects on the early growth of tomato plants. Out of all the treatments, treatment no. 11 showed the best results and had the highest concentration of PSB. The highest plant height recorded was 91.5cm, the highest no of fruits recorded was 26.5, and the highest weight recorded was 1193.50g. Upon the analysis of molecular characterization, based on 16S rRNA gene sequence comparisons and phylogenetic positions it was closest (on the adjacent branch in the phylo genetic tree) to the *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence. The Genomic Islands study of antimicrobial resistance genes was also performed in different strains of *Bacillus* including, three pathogenic (*Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5 DNA, and *Bacillus thuringiensis* Bt407) and one non-pathogenic (*Bacillus subtilis* strain NCIB 3610) species. The results of the study showed absence of Genomic Island for Antibiotic resistant gene in *Bacillus anthracis* genome while other three organisms showed presence of GIs. This study concluded that PSB can be used as a potential biofertilizer to increase the growth and yield of the tomato plant.

**Keywords:** Phosphate solubilizing bacteria, rhizospheric soil, tomato plant growth, root-shoot ratio





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## INTRODUCTION

In a terrestrial ecosystem, soil microorganisms play a significant role in the recirculation of nutrients in the rhizosphere of plants, which is essential for the long-term viability of the soil. Phosphorus is an essential macronutrient that is necessary for plant growth and development. It affects root growth, stalk and stem strength, crop maturity, and nitrogen fixation in legumes on a macro level. It is a component of biological molecules like DNA, RNA, ATP, and phospholipids. Phosphorus (P) is the second most important macronutrient for plant development in soil after nitrogen, and a lack of P restricts plant growth (Zhang *et al* 2017). P is one of the less prevalent elements in the lithosphere (0.1% of total) when compared to other key macronutrients (apart from N). Chemical fertilizers were a key component of the Green Revolution, but their over usage has reduced soil fertility and degraded the environment. Because the free phosphorus content (the form available to plants) is often less than 10  $\mu\text{M}$  even at pH 6.5 where it is most soluble, many soils around the world are P-deficient (Gyaneshwari *et al.*, 2002). However, due to its essential function in energy transfer (such as ATP), cell structure (phospholipids), metabolism, and signalling, adequate P nutrition is required for all microorganisms (Jones and Oburger, 2011). It is generally recognized that many bacterial species, especially those found in the plant rhizosphere, have the ability to positively influence plant growth. Because of this, many researchers have been concentrating on their usage as biofertilizers or control agents for agriculture improvement for a number of years. The term "plant growth promoting rhizobacteria" (PGPR) has been used to describe this group of bacteria. Strains from genera like *Pseudomonas*, *Azospirillum*, *Burkholderia*, *Bacillus*, *Enterobacter*, *Rhizobium*, *Erwinia*, *Serratia*, *Alcaligenes*, *Arthrobacter*, *Acinetobacter*, and *Flavobacterium* are included in this group (Rodríguez and Fraga, 1999). In canola, lettuce, and tomato, strains of *Pseudomonas putida* and *Pseudomonas fluorescens* have boosted root and shoot elongation (Hallet *et al.*, 1996).

Wheat yield improved by up to 30% with *Azotobacter* inoculation, up to 43% with *Bacillus* inoculants (Kloepper *et al.*, 1989) and by up to 10% in field trials when *Bacillus megaterium* and *Azotobacter chroococcum* were combined. In several nations, bacterial inoculants have been employed to boost plant yields, and there are already commercial solutions on the market. These bacteria are able to thrive in media with calcium phosphate complexes as their only source of phosphorus, solubilize and assimilate a significant portion of the phosphorus, and release a significant amount of phosphorus. By synthesizing organic acids, phosphorus is solubilized and released by micro organisms. This reaction, leaves a halo or clear zone on the plate, is used to measure how well these bacteria are able to dissolve P. Undoubtedly, the selections of highly efficient PSB strains as prospective inoculants will be a promising strategy to release huge amount of P from soil to ameliorate the current state of extensive chemical fertilizer usage. The use of phosphate-solubilizing bacteria (PSB) is useful for sustainable agriculture practices due to the harmful environmental effects of chemical fertilizers and high cost (Gyaneshwari *et al.*, 2002). Through acidification, chelation, exchange processes, and the generation of gluconic acid, PSB might transform these insoluble phosphates into forms that plants could use (Chunget *et al.*, 2005; Gulati *et al.*, 2010). They may also stimulate plant growth by secreting hormones specific to plants, such as cytokinin and indole acetic acid (Sadaf *et al.*, 2009). The investigated phylogenetics is used to establish the historical relationships between several species or genes and to illustrate these relationships in the form of a branched tree known as a phylogenetic tree (Hillis, 1997). Using genome-based phylogenetic analysis, it is possible to understand the genetic changes responsible for the evolution of species. The objective of this study is to determine the effect of phosphate solubilising bacteria on the growth of tomato (*Solanum lycopersicum*) plant under pot conditions and to predict the genomic island of the isolated strain.

## MATERIALS AND METHODS

### Isolation of Phosphorus Solubilising bacteria and its morphological analysis

The roots of tomato (*Solanum lycopersicum*) plant and the immediate surrounding soil were collected in sterile sample bags from the field of SHUATS, Prayagraj, Uttar Pradesh. The phosphate solubilizing bacteria were isolated by suspending 10g of rhizosphere soil into 90ml of distilled water. Then, an aliquot of 0.1 ml of serially diluted



**Shipra Kumari**

rhizospheric soil suspension was inoculated on Pikovskaya's medium (pH 7.2) (Pikovskaya, 1948), and incubated at 37° C for 24-48 hrs. The colonies that produced clearing zones in the PVK agar plates were isolated, to study the cell morphology by using Gram staining (Coico, 2006).

**Preparation of Bacterial Broth Culture**

The bacterial colony was then inoculated in PVK broth after the analysis of morphological characteristics. Roots of the *Solanum lycopersicum* var. *pusa ruby* were dipped in the PSB broth of different concentration as shown in Table-1 and effect of PSB was determined in terms of various growth parameters which was height of plant, no of fruits per plant and weight of fruit per plant. A total of twenty-four plants that were planted, two tomato plants (*Solanum lycopersicum*) for each treatment were taken to see the effects of the phosphate solubilizing bacteria. The parameters for tomato plant growth were recorded from the initial time i.e., 15 days to the harvesting time i.e., 90 days. There were total 12 treatments of tomato plant with the phosphate solubilizing bacteria designated with T having numbers in subscript starting from T<sub>0</sub> to T<sub>11</sub>.

**Molecular Characterization**

The Genomic DNA, was extracted from the bacterial isolates by the kit method [Nucleo-pore Gdna Bacterial Mini Kit (Cat. NP-7006D)] according to manufacturer's instructions. Further, Agrose Gel Electrophoresis was done to confirm the presence of DNA. DNA quantification and quality determination was done by using UV Spectrophotometer. The PCR reaction mixture was prepared as per the contents mentioned in Table-2. Then, the reagents were combined in the 0.5 ml tube or in the 0.2 ml PCR tube followed by keeping the reagents on ice. Tube was tapped gently to mix or spined briefly in micro-centrifuge to get all contents to bottom, then placed on ice until ready to load in the thermo cycler. The tubes were then placed in thermal cycler and were subjected to 35 cycles in a thermal cycler with the following program: initial denaturation at 94°C for 3 minutes which was followed with 35-cycle consisting of denaturation at 94°C for 30 seconds, annealing at 60°C for 30 seconds, and elongation at 72°C for 2 minutes. The reaction was completed with an extension step at 72°C for 5 minutes.

Upon completion of PCR, the samples were kept at 4°C. Then, the DNA was prepared for loading by addition of 5µl gel loading dye with 6µl of PCR product. The product by Agarose gel electrophoresis on 1.2% gel was analyzed and the size markers in at least one well on the same gel were included. The amplification product was analyzed at 50 V and the gel was observed on trans-illuminator for the amplified bands in the middle of the gel. The sequence of the 16S rRNA amplified product was done by Sanger's Sequencing Method. The sequence obtained was further analyzed and identified using Bio informatic tools viz., BLAST program, Bio Edit and MEGA X. The sequences obtained in this study were examined using the BLAST algorithm to detect closely related bacteria by comparing a nucleotide query sequence against a public nucleotide sequence database (Yu *et al.*, 2011). The National Center for Biotechnology Information (NCBI) database was used for BLAST analysis on the 16S rRNA nucleotide sequences [www.ncbi.nlm.nih.gov/blast](http://www.ncbi.nlm.nih.gov/blast). The sequence with maximum percent identity was known to have maximum similarity with the query sequence were downloaded from the NCBI database. The identified species and the closely related species were then used to construct phylo genetic tree by MEGA X and sequence alignment is done by Clustal W, followed by Genomic Island Analysis (Bertelli *et al.*, 2019).

**Statistical Analysis**

All data in the present study were subjected to analysis of variance (ANOVA), F-cal and F-Tab were calculated on Excel sheet.

**RESULT AND DISCUSSION****Plate assay and staining**

The plates of the Pikovskaya's (PVK) medium that were cultured, resulted in the growth of bacteria forming colonies and producing halo zones surrounding it, which indicated that the phosphate in the media was solubilized as shown





**Shipra Kumari**

in Fig-1. The bacteria able to solubilize phosphate were determined when zones of clearance were observed surrounding the colonies. The halo zones formed is the product of solubilizing insoluble phosphate due to the release of organic acids in the media. The Gram staining results indicated that the bacteria were gram-positive rods as shown in Fig-2. Other than this, they were found singly which are the attributes of *Bacillus* species.

**Growth parameters**

The twenty-four plants treated with twelve treatments were observed for their growth, flowering and fruiting stage. The first parameter was the height of the plant. Among these, the treatment that was highly effective was T<sub>11</sub> with 91.50 cm plant height and the least effective treatment was T<sub>0</sub> with 79.50 cm plant height as shown in Table-3. Fig-3 shows this data recorded in the form of a bar diagram plotted against height of plant in cm. The second parameter was the number of fruits per plant to determine vegetative growth of tomato plant. Among these, the treatment that was highly effective was T<sub>10</sub> with an average of 27.50 fruits per tomato plant and the least effective treatment was T<sub>0</sub> with an average of 18 fruits per tomato plant as shown in Table-4. Fig-4 shows this data, recorded in the form of a bar diagram plotted for 12 treatments against number of fruits per tomato plant. The third parameter was the weight of fruits per plant to determine vegetative growth of tomato plant. Among these, the treatment that was highly effective was T<sub>11</sub> with the fruit weight of 1193.50 gm and the least effective treatment was T<sub>5</sub> with the fruit weight of 567.50 gm as shown in Table-5. Fig-5 also shows this data, recorded in the form of a bar diagram plotted for 12 treatments against the weight of fruit in grams.

**Molecular Characterization**

According to 16S rRNA sequence analysis, the query sequence was found closely related to partial sequence of 16S ribosomal RNA gene of *Bacillus subtilis* strain NBRIYE1.3 with an accession number: MK168629 (Liu *et al.* 2015). In order to identify the bacteria from its query sequence as phosphate solubilizing bacteria on the basis of its 16S rRNA as well as phylogeny, phylogenetic tree as shown in Fig-6 was constructed using MEGA X.

**Bioinformatic analysis**

The species was identified as *Bacillus subtilis* as it was closest (on the adjacent branch in the phylogenetic tree) to *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence having accession no. MK168629.1. Four *Bacillus* species were selected for their Genomic Island (GIs) study are – *Bacillus subtilis* strain NCIB 3610, *Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5DNA, *Bacillus thuringiensis* Bt407. In the study we identified and analyzed GIs of antimicrobial resistance genes in the different strain of *Bacillus* including three pathogenic (*Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5 DNA and *Bacillus thuringiensis* Bt407) and one non-pathogenic (*Bacillus subtilis* strain NCIB 3610) species using Island Viewer 4. The results of the study showed absence of Genomic Island for Antibiotic resistant gene in *Bacillus anthracis* genome while other three organisms showed presence of GIs. Their presence was also marked by presence of high proportion of hypothetical proteins in this region as shown in the Fig-7 to Fig-13, encircled in RED, result of *Bacillus cereus* 03BB102 also shows presence of transposases, which are the gene responsible for mobility and *Bacillus thuringiensis* Bt407 showed presence of integrase gene in the list marked by circle in GREEN. Integrase gene facilitates integration any new gene in the region as shown in Fig-9 and Fig-13.

**DISCUSSION**

Because soil phosphorus (P) is crucial for plant development, a lack of P restricts plant growth. Despite the addition of artificial fertilisers to the soils, plants might use phosphatic fertilizers sparingly and in small quantities. In this instance, choosing a highly effective PSB will essentially increase the amount of phosphorus in the plant rhizosphere (Zhang *et al.*, 2017). Therefore, PSB can be thought of as one type of rhizobacteria that promotes plant development and is frequently used as an alternative to typical biofertilizers. Establishing sustainable agriculture methods that could preserve the soil system's long-term ecological equilibrium is urgently needed. PSB are seen as one potential substitute for chemical fertilisers in this situation. Additionally, using the microorganisms as bio



**Shipra Kumari**

fertilizers for crop development will be considered a favourable signal of the presence of P-solubilizing microbial population in soils (Majeed et al., 2015). In the present research, soil samples from tomato plant's, rhizospheres were examined for the presence of PSB on Pikovskaya's medium. The different concentrations of isolated PSB broth showed positive effect on several growth parameters of plant such as height of plant, weight of fruit per plant, number of fruits per plant. The formation of organic acids and the acidification of the medium are the two main mechanisms involved in the solubilization of insoluble phosphate. The usage of phosphate solubilizing microorganisms has risen to improve the uptake of phosphorus as well as the yielding of crops because of their capacity to solubilize phosphate from phosphorus that are present in soil but inorganic in form (Khalid et al., 2004). Our results confirm that the phosphorous solubilizing bacteria can be isolated from immediate soil surrounding tomato plant. The effectiveness of the *Bacillus* spp. against the *Fusarium*-induced tomato plant wilt was examined in several researches. *Bacillus* species were found to be effective against fungus in agricultural fields in this investigation. They helped tomato plants grow more quickly as well (Ajilogba et al., 2013). Certain other species of *Bacillus* such as *Bacillus circulans* CB7 is responsible for increasing the solubilization of phosphorous and thereby increasing the growth of tomato plant by producing auxin. They improved roots' capacity for root development, which increased nutrient intake (Mehta et al., 2015). According to reports, the *Bacillus* species enhance the yield of spinach (Çakmakçi et al., 2007), sugarbeet (Çakmakçiet al., 2006), wheat (deFreitas, 2000), and maize (Pal, 1998). A similar increase in growth and P uptake of tomato plants due to inoculation of PSB strains was observed by (Poonia and Dhaka, 2012), (Turan et al., 2007). Numerous techniques are used to identify genomic islands, and they provide the organisms a certain distinguishing trait (Dobrindt et al., 2004; Vernikos and Parkhill., 2008).

The genomic island (GI) is part of a genome that has evidence of horizontal origins (Langille et al., 2010). Horizontal gene transfer has been recognized as a universal event throughout bacterial evolution (Hentschel and Hacker, 2001; Ochman, 2001; Ochman et al., 2000) and it is the primary mechanism for the spread of antibiotic resistance in bacteria (Gyles and Boerlin, 2014). In the study we identified and analyzed GIs of antimicrobial resistance genes in the different strain of *Bacillus* including three pathogenic (*Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5 DNA and *Bacillus thuringiensis* Bt407) and one non-pathogenic (*Bacillus subtilis* strain NCIB 3610) species. The study's findings revealed that the genome of *Bacillus anthracis* does not have a genomic island (GI) for the antibiotic resistance gene, whereas the genomes of the other three organisms contained. They were also distinguished by the region's high concentration of fictitious proteins. From the present study, we demonstrate that the natural subtropical soil supports a diverse group of potential phosphate solubilizing bacteria. These P solubilizing soil bacteria could serve as efficient biofertilizer candidates for improving the P-nutrition of crop plants. The advantage of using natural soil isolates over the genetically manipulated or the one which has been isolated from a different environmental set up is the easier adaptation and succession when inoculated into the plant rhizosphere (Chen et al., 2006).

**CONCLUSION**

Out of all the treatments, the best effect of treatment 11 was observed in the tomato plants. The highest plant height recorded was 91.5cm, the highest no of fruits recorded was 26.5, The highest weight recorded was 1193.50g. Molecular characterization analysis identified bacterial species as *Bacillus subtilis* as it was closest (on the adjacent branch in the phylogenetic tree) to *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence having accession no. MK168629.1. Upon the analysis of Genomic Islands (GIs), only *Bacillus anthracis* had the absence of Genomic Island for Antibiotic resistant gene, while other three strains (i.e., *Bacillus cereus*, *Bacillus thuringiensis* and *Bacillus subtilis*) showed the presence of GIs. The query sequence was uploaded on NCBI and accession number given was LC66322.1. The tested strains of *Bacillus* tend to enhance the growth of tomatoes (as measured by plant height, number of fruits per plant, and weight of fruits per plant). The selected *Bacillus* strains also enhanced the uptake of phosphorous by tomato plants and the available phosphorous content in the soil compared to the control. This study concluded that PSB can be used as a potential bio fertilizer to increase the growth and yield of the tomato plant. And will also help in minimizing chemical fertilizer application, reducing environmental pollution, and promoting sustainable agriculture.





Shipra Kumari

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## Shipra Kumari

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**Table-1 Concentration of PSB for the treatment**

S.No.	Treatment Name	Concentration of Treatment
1	T <sub>0</sub>	Control
2	T <sub>1</sub>	1%
3	T <sub>2</sub>	2%
4	T <sub>3</sub>	5%
5	T <sub>4</sub>	15%
6	T <sub>5</sub>	20%
7	T <sub>6</sub>	25%
8	T <sub>7</sub>	30%
9	T <sub>8</sub>	35%
10	T <sub>9</sub>	40%
11	T <sub>10</sub>	45%
12	T <sub>11</sub>	50%

**Table-2 PCR reaction mixture**

S.No.	CHEMICAL	STOCK	WORKING
1	Template DNA		5µl
2	PCR buffer	10x	2µl(1x)
3	dNTP	2.5mM	2.5µl (0.2 mM/L)
4	Primer	100 ppm	
	Universal forward primer		1µl (8 ppm)
	Reverse primer		1µl (8 ppm)





## Shipra Kumari

5	Taq polymerase	5U	1 $\mu$ l	
6	Distilled water		7.5 $\mu$ l	
	Total		20 $\mu$ l	

**Table-3 Effect of bacterial (PSB) treatment on plant height (in cm) of tomato after 15 and 90 days**

Treatment	Plant height (in cm)	
	Initial	Harvesting time
T <sub>0</sub>	19.50	79.50
T <sub>1</sub>	18.50	80.50
T <sub>2</sub>	17.25	81.00
T <sub>3</sub>	15.50	85.50
T <sub>4</sub>	17.75	86.00
T <sub>5</sub>	16.50	87.25
T <sub>6</sub>	20.00	87.50
T <sub>7</sub>	18.25	89.00
T <sub>8</sub>	19.00	89.50
T <sub>9</sub>	21.00	89.50
T <sub>10</sub>	15.75	91.25
T <sub>11</sub>	15.25	91.50
F-test	S	S
F-Tab	2.818	2.818
F-cal	7.202	4.005

**Table-4 Effect of bacterial (PSB) treatments on vegetative growth of tomato (number of fruits per plant) after 90 days**

S.No.	Treatments	Number of Fruits
1	T <sub>0</sub>	18.00
2	T <sub>1</sub>	20.50
3	T <sub>2</sub>	21.00
4	T <sub>3</sub>	21.00
5	T <sub>4</sub>	20.50
6	T <sub>5</sub>	22.50
7	T <sub>6</sub>	22.00
8	T <sub>7</sub>	21.00
9	T <sub>8</sub>	24.00
10	T <sub>9</sub>	25.50
11	T <sub>10</sub>	27.50
12	T <sub>11</sub>	26.50
13	F-cal	4.350
14	F-Tab	2.818
15	F-test	S

**Table-5 Effect of bacterial (PSB) treatments on vegetative growth of tomato (weight of fruits per plant in gram) after 90 days**

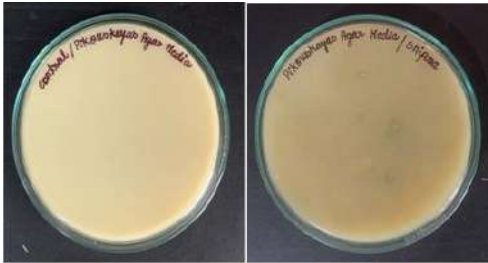

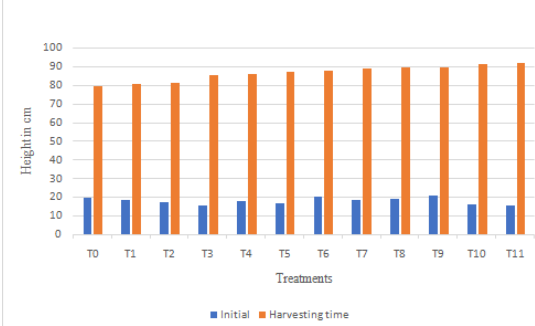
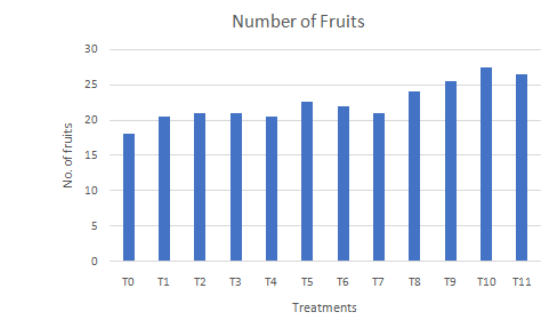
S.No.	Treatments	Weight of fruits (in gm)
1	T <sub>0</sub>	912.50
2	T <sub>1</sub>	990.00





**Shipra Kumari**

3	T2	950.00
4	T3	1002.50
5	T4	974.50
6	T5	567.50
7	T6	992.50
8	T7	959.00
9	T8	1087.00
10	T9	1147.50
11	T10	1085.00
12	T11	1193.50
13	F-test	S
14	F-Tab	2.818
15	F-cal	5.931

	
<p><b>Fig-1</b> PSB produced a clear halo zone around the colony in PVK media</p>	<p><b>Fig-2</b> Isolate observed under 40X-magnification after gram staining, observed shape was rod and colour attained was crystal violet</p>
	
<p><b>Fig-3</b> Effect of bacterial (PSB) treatments on height (in cm) of tomato plant after 15 and 90 days</p>	<p><b>Fig-4</b> Effect of bacterial (PSB) treatments on vegetative growth of tomato (numbers of fruits) after 90 days</p>







Shipra Kumari

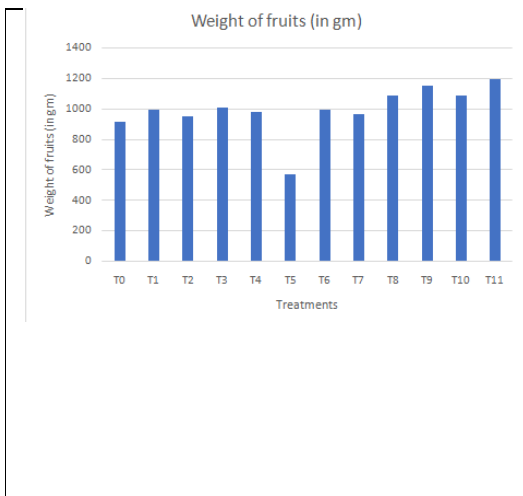


Fig-5 Effect of bacterial (PSB) treatments on weight of fruit (in gm) of tomato plant after 90 days

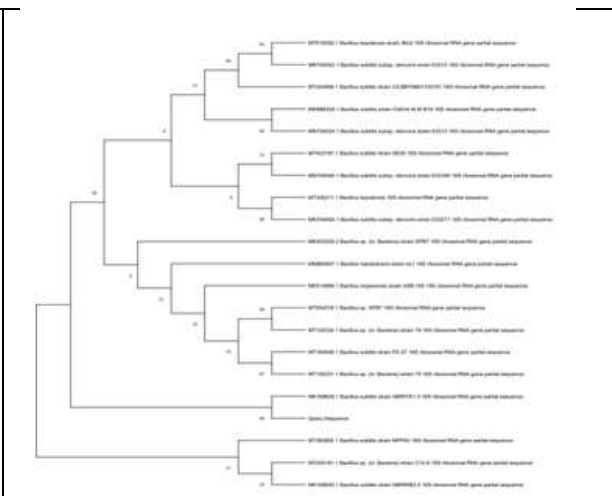


Fig-6 Neighbor-joining tree showing the phylo genetic relationships of query 16S rRNA gene sequences with the database sequences identifying *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence having accession no. MK168629.1 as the closest homolog

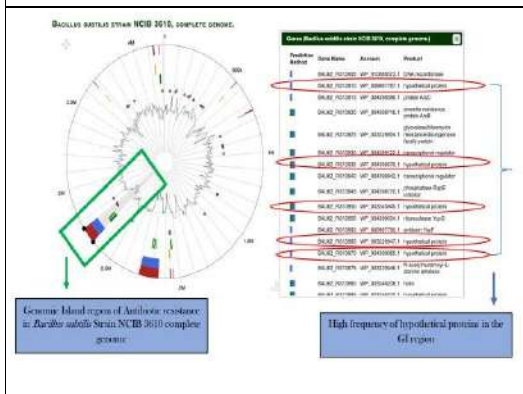


Fig-7 Results of Island Viewer 4 Prediction Tool, showing a circular representation of *Bacillus subtilis* strain NCIB 3610 complete genome with highlight on the resistance gene indicated by green box

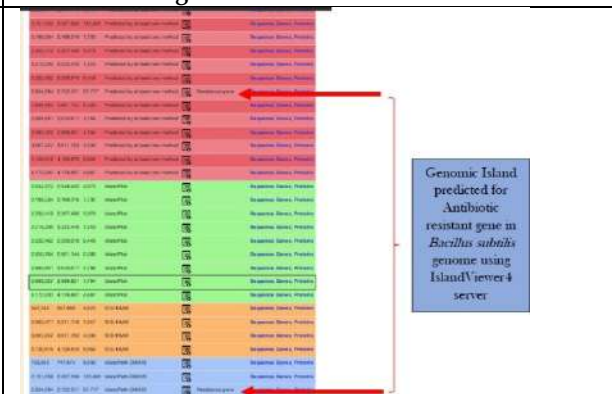


Fig-8 Results of Island Viewer 4 Prediction Tool result showing list of predicted genomic Island regions in *Bacillus subtilis* Strain NCIB 3610 complete genome





Shipra Kumari

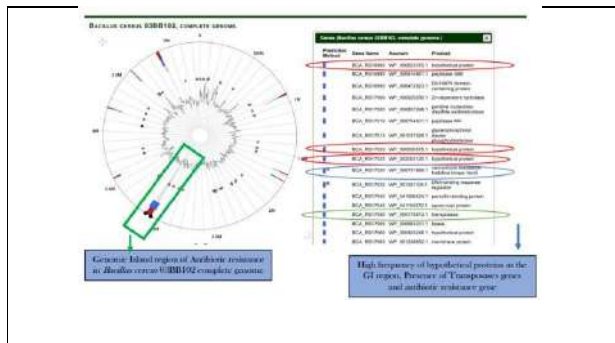


Fig-9 Results of Island Viewer 4 Prediction Tool, showing a circular representation of *Bacillus cereus* 03BB102 complete genome with highlight on the resistance gene indicated by green box.



Fig-10 Results of Island Viewer 4 Prediction Tool, showing list of predicted genomic island regions in *Bacillus cereus* 03BB102 complete genome with colour highlights of the method used for prediction i.e., red indicating Integrated method, Blue for Island Path-DIMOB, orange for SIGI-HMM and green for Island Pick

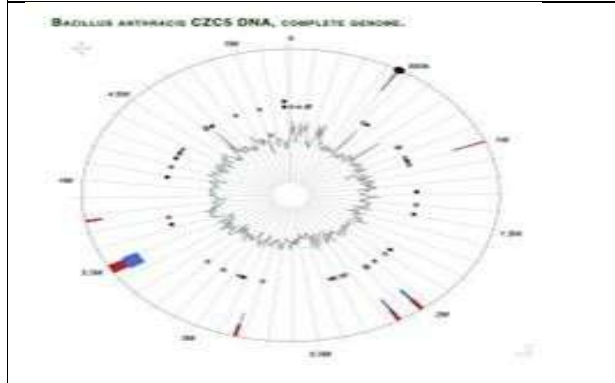
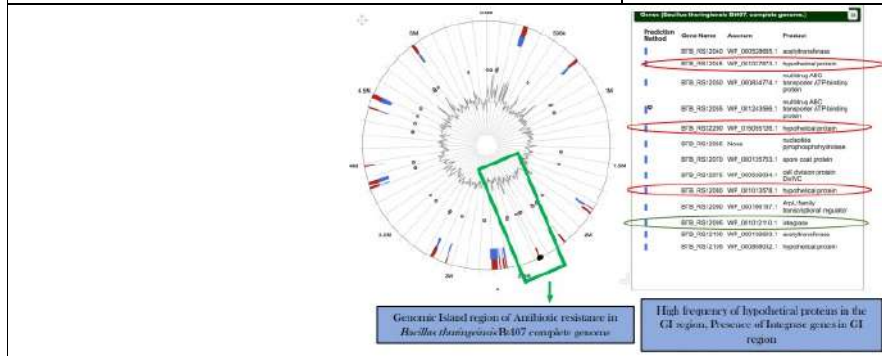


Fig-11 Result of Island Viewer 4 Prediction Tool result showing a circular representation of *Bacillus anthracis* CZC5 DNA complete genome with highlight on the resistance gene indicated by green box.



Fig-12 Result of Island Viewer 4 Prediction Tool result showing list of predicted genomic island regions in *Bacillus anthracis* CZC5 DNA complete genome





## IoT and Deep Belief Network-based Object Detection for Visually Impaired People

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### ABSTRACT

Visually Impaired People (VIP) has a unique set of obstacles. Because to their restricted surroundings and difficulties seeing what is going on around them, these people are less active in a number of areas, including education and transportation since they rely only on their own intuition. Identification of a currency's denominational value is done through the process of money and object recognition. For an average person, it is a simple and uncomplicated activity, but for a VIP, it is difficult. The primary objective of this work is recognizing object and identify the currency for VIP by using Deep Belief Network. This work also includes the RFID based bank account balance conveying system for VIP. This work used RFID tag for reading the bank account details and give bank balance to VIP.

**Keywords:** Visually Impaired Person (VIP), Deep Belief Network, Object Recognition, Currency Detection, RFID.

### INTRODUCTION

Helping and assisting people who are visually impaired is one of the most popular vocations in the world today. 161 million of the 6.7 billion people on the planet have vision impairments. Depending on their distinct degree of vision, each VIP has a unique set of obstacles. Because to their restricted surroundings and difficulties seeing what is going on around them, these people are less active in a number of areas, including education and transportation since they rely only on their own intuition. The societal structure and economic system are designed to provide opportunity,





**Prabhavathi et al.,**

employment and enjoyment for sighted people while excluding the visually handicapped from this system. Banknotes are one of the general ways carried out all over the world to perform exchanges for exchanging or trade of currency among individuals. In international trade marketplaces, many monetary types are seen for international exchange. Paper money has the drawback of perhaps being phoney. Fake money is deemed to be misrepresentation when it is supplied without the lawful consent of the state or government. Embrace anti-falsification measures, such as the fine details of raised intaglio printing on notes that make it simple for non-specialists to identify fakes.

## LITERATURE REVIEW

A. Dionisi et al. presented an RFID device for the blind to reveal items and it was specifically designed to search for medications in a cabinet at home. This gadget makes searching easier by telling you how far away or close an object is and how distant it is from you. The tool may give the user an auditory signal for pharmaceutical identification so they can locate the needed item as speed as feasible. [6] Provides a description of an RFID-based blind assistance system. Each bus in this place has an RFID tag attached to it that provides the bus number and upcoming destinations. Similarly, every individual who is blind should own a portable gadget. A headset, control subsystem and RFID reader are all included in the portable gadget. The primary concept behind this system is that as buses approach, an RFID reader on a portable device would sense them and scan the information from their tags. Each blind person will receive a customized audio message about the arriving buses through their headset using the bus information. Yet, using the recommended method, the driver is oblivious to the fact that there are blind people at the station. Sungwook et al. developed an effective and fast method for distinguishing currencies [7].

This information was considered to be an essential component because different bank currencies had varying sizes. 55 currencies from five different nations in 30 distinct classifications were used to test this strategy. The specifics of the SURF method for the local, compact, and invariant representation of natural pictures were carefully examined and investigated by Julien Rabin and colleagues [17]. Computer vision is quite interested in its use. The outcomes of their studies therefore demonstrated the efficacy and robustness of their method. Ms. Rumi Ghosh et al. introduced Indian Currency Note with Diverse Recognition Techniques. In various applications, programmed plans for paper cash recognition were notable by the establishment of present-day banking administrations. A computerized paper cash acknowledgement system may be incredibly useful in banking and other areas of business. The falsification of paper money has been a problem for every country's monetary system for many years and India was no exception. In this article, different techniques for the acknowledgment of paper money are depicted. A proficient money acknowledgment framework was imperative for the computerization in numerous parts, for example, candy machine, rail way ticket counter, banking framework, shopping centre, cash trade administration and so on. An effective methodology for money acknowledgment relies on highlight.

## SYSTEM METHODOLOGY

### RASPBERRY PI

A GPU, multi core processor, Ethernet interface, I/O peripherals, ROM, USB host, DDR Memory and micro HDMI are all included in the Raspberry Pi. This project used the Raspberry Pi board in bus indication system because it can help with many forms of process automation. A Raspberry Pi 4 board will supply power to the smart bus indication system.

#### A. IR Sensor

An IR sensor emits infrared light, which is subsequently absorbed by the target item before being sent to the receiver.

#### B. WEB CAM

A webcam input tool for digital picture capturing. To the IR Sensor, they are sent. This work used Web cam for capturing the object, currency and reading RFID tag for VIP.





### C. RFID

RFID, or radio frequency identification, is utilized in a location tracking system to track the object and cloud computing is employed to increase calculation speed while keeping hardware costs low. A transponder or tag is attached to the luggage in order to track it inside the museum. The impact of various offset angles on tag read rates was investigated. The findings indicate that as the offset angle is increased, the reading rate falls. About 60 degrees is the effective recognition angle and the effect is better around 45 cents. The reading rate significantly decreases beyond 75 cents. As a result, there are specific guidelines for the placement of cultural artifacts and reading angles in order to guarantee their veracity. This work used RFID tag for reading the bank account details and give bank balance to VIP.

### D. SPEAKER

One of the most popular output devices is a computer connected to speakers, which produce sound. While some speakers may only be connected to computers, others can be used with any type of sound system. The sound card of the computer generates a signal that is utilized to make sound through the computer speaker. Speakers' main goal is to provide audio output for the listener. The blind individual is given audio instructions on where the bus is located. Users who are blind can change the language, speech tempo and volume to suit their preferences.

### E. DEEP BELIEF NETWORKS (DBN) ARCHITECTURE

This research work proposed methodology is centered on Deep Learning, which as of late has seen extensive improvement in errands identified with picture acknowledgment. This procedure can support the two individuals and PC perceives a phony currency note by means of an image of the equivalent progressively. It is additionally conceivable to actualize the proposed program, robotized counterfeit currency acknowledgment framework, as an application on the cell phone that can assist VIP with separating among phony and unique currency notes. Hinton as of late proposed DBNs alongside a solo covetous learning calculation to make each layer in turn for the system. This strategy is an effective method of learning (an in any case confused model) by coordinating successively took in various and less complex models. The DBN preparing cycle is appeared in figure 7. DBN with one layer of data,  $x$  and three layers of  $h_1$ ,  $h_2$ ,  $h_3$ . A DBN's number of layers can be insatiably increased. Each new layer layered on head of the DBN will show the exhibition of the past layer and look to remove more elevated level conditions between the first factor inputs, consequently improving the system's capacity to catch the fundamental regularities in the information. The objective of the base layers is to separate low-level highlights from input information, while the upper layers should gradually refine recently learned ideas, consequently producing progressively theoretical ideas that explain the first info perceptions. The preparation procedure, otherwise called pre-preparing, is basically unaided, empowering the framework to gain from information straightforwardly non-direct complex planning capacities without depending on human-made highlights. Regardless, the top-layer yield can be handily taken care of to a customary directed classifier.

## RESULT AND DISCUSSION

The comparison analysis is performed in order to prove that our proposed method for Currency recognition and classification of currency between genuine or fake class works best when compared to the other existing. Many different methods are analyzed in the section which mainly utilized currency detection and classification. The previously develop methods are not provide the best results for the same. Some of the existing methods are CNN, KNN and ANN. to examination the presentation of the existing technique the statistical parameters like sensitivity, specificity and accuracy. Above figure 8 shows graphical presentation of analysis of sensitivity in proposed method. From the graph it is found that the value for sensitivity for very low is found to be 0.94 which is found to be higher on comparison to other classes. From figure 8, the sensitivity of the proposed methods is 0.94, 0.91, 0.90 and 0.70. In the above mentioned figure 10 the graphical representation for the statistical measurement namely specificity is provided. The graph is plotted against various classes in x-axis and value of precision in y-axis. These classes were







Prabhavathi et al.,

categorized as fake currency or not. From the graph it is found that the value for specificity for very low is found to be 0.75 which is found to be higher on comparison to other classes. The second and third class was found to be similar but less as compare to first class. Following that fourth greater category was found to be low. From figure 10 the specificity of the proposed methods are 0.96, 0.90, 0.88 and 0.75. The other category of classes will lie subsequently. In figure 10 analysis of accuracy is provided in graphical format. In the x axis the classes is represented and in y axis the value of accuracy is represented. These classes were categorized as affected or not in terms of accuracy. The second greater category is found to be very high. The third greater category following that is found to be low. Subsequent the next two categories lie. From figure 10 the accuracy of the proposed methods are 0.96, 0.91, 0.87 and 0.76.

## CONCLUSION

Visually Impaired Person (VIP) has a unique set of obstacles. Because to their restricted surroundings and difficulties seeing what is going on around them, these people are less active in a number of areas, including education and transportation since they rely only on their own intuition. Identification of a currency's denominational value is done through the process of money and object recognition. For an average person, it is a simple and uncomplicated activity, but for a VIP, it is difficult. The primary objective of this work is recognizing object and identify the currency for VIP by using DBN. The efficiency of this DBN is compared with CNN, ANN and KNN. From the result observation, proposed DBN is produced efficient results than other algorithms.

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### Algorithm 1. Pseudo code for DBN

#### Train Neural Network

```

For i=1: numepochs
kk = randperm(m);
For l = 1: numbatches
batch_x = train_x(kk((l-1)*batchsize +1: l*batchsize), :);
batch_y = train_y(kk((l-1)*batchsize +1: l*batchsize), :);
%performas a feedforward pass
%returns a net structure with updated
nn = nnff(nn, batch_x, batch_y);
%performas a backpropagation pass
%returns a net structure with updated delta of weights
nn = nnbp(nn);
%updates weights and biases with calculated gradients
%returns a net structure with updated weights and biases
nn = nnapplygrads(nn);
End
End
Evaluate and Test Neural Network
Classify signals and identify faults

```





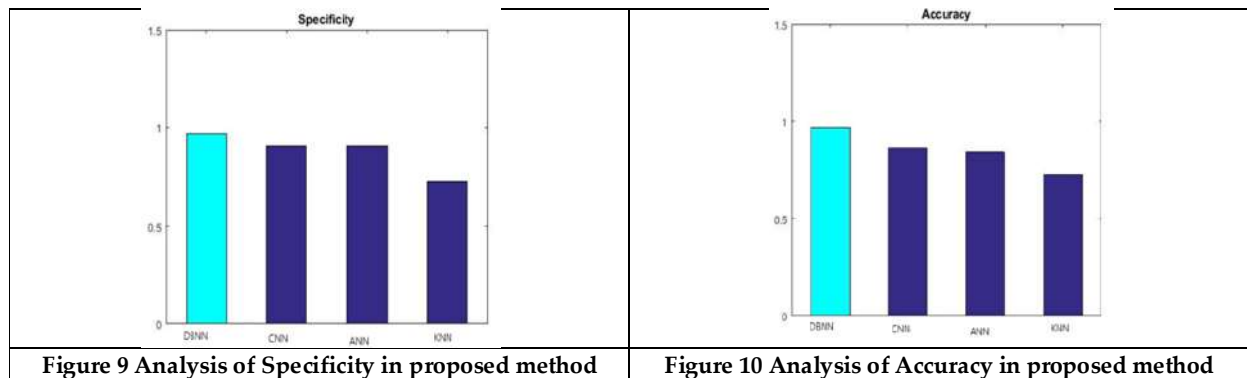
Prabhavathi et al.,

<p>Figure 1 Block Diagram.</p>	<p>Figure 2 Raspberry Pi</p>
<p>Figure 3 IR Sensor</p>	<p>Figure 4 Web Cam</p>
<p>Figure 5 RFID Tag</p>	<p>Figure 6 Speaker</p>
<p>Figure 7 Training process of a Deep Belief Network (DBN)</p>	<p>Figure 8 Analysis of sensitivity in proposed method</p>





Prabhavathi et al.,





## A New Passive Islanding Detection Method for Hybrid Distributed Generation System with Phase Angle between Negative Sequence Voltage and Current

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### ABSTRACT

In this paper a new passive islanding detection method is proposed for Hybrid Distributed generation system during unintentional islanding. As per DG interconnection standards, it should be detected within 2 Sec after islanding. In this paper the islanding is detected by measuring the phase angle between the negative sequence voltage and current. This method can detect islanding during zero power imbalances. Most of passive islanding methods are suffering with the Non detection zone (NDZ) but this method is free from NDZ. The test system is simulated with different active power imbalances and islanding is detected earlier than other passive methods. The results simulated on MATLAB/ Simulink show the strength of the proposed method.

**Keywords:** Hybrid Distributed Generation, Negative sequence voltage, Negative sequence current, Phase angle, Islanding





## INTRODUCTION

Distributed power generation systems are becoming more common as a result of the increased demand for electricity and the requirement to reduce the impact on the environment from traditional sources of power production in which fossil fuels or nuclear fuel are commonly used. With distributed generation integration with the main utility, the main issue is the islanding situation [1]. Islanding operation occurs when DG continues to supply power to the network, even if power is interrupted from the main grid [2]. Islanding is a situation in which a distribution system becomes electrically isolated from the remainder of the power system, due to a fault at upstream side or any other disturbance, and yet continues to be energized by the DG connected to it. Several researchers have proposed many methods for islanding detection. There are four types of islanding detection techniques: 1) passive, 2) active and 3) communication based and 4) hybrid techniques. Monitoring of the different system parameters like voltage, frequency, impedance, THD at any desired location comes under the passive techniques in which these parameters are compared with the pre-specified threshold to decide about the islanding. Passive methods are preferred, since they use the information that is available on the DG without influencing the normal operation of the DG. The major demerit of passive techniques is depending on threshold values. For higher threshold value, islanding situations may not detect properly and for a lower threshold value other non islanding conditions may be treated as islanding condition. Various passive methods that have been presented so far are over/under voltage [4-8]], the rate of change of frequency (ROCOF), the rate of change of power (ROCO), total harmonic distortion of current, the rate of change of voltage (ROCOV) and the phase shift method [8-25] . In case of active method, a small disturbance is intentionally introduced into the system and upon the feedback it can be determined whether islanding occurs or not.

But a large change in the system parameters will occur in case of islanding as the main utility is absent. Active islanding methods have very small NDZ. But the quality of the power is distorted due to the injection of external disturbance. Some of the islanding methods are slip-mode frequency shift, active Frequency Drift, current injection and voltage shift method [26-31] in case of communication based technique, communication based islanding detection methods depend on the communication links between the DGs. This method has negligible NDZs along with the highest possible accuracy, but the drawback is that it is more expensive as it requires a high speed operation. In this paper, a passive islanding detection method is presented using the absolute value of the angle between the negative sequence voltage and current at the DG end. The voltage and current data are sampled at a sampling frequency of 1 kHz. The Least square based technique is used to calculate the voltage and current phasor. The negative sequence components of voltage and current are calculated. Islanding condition is identified by estimating the absolute value of the angle between negative sequence voltage and current. The proposed method work well during zero power mismatches. The performance of the technique is tested for islanding and different non-islanding conditions like capacitor switching, load switching, etc. at the DG terminals.

### System under study

A radial distribution system (25 kV, 50 Hz) as shown in Fig. 1 is considered. In this system, 10 MVA is taken as the base power. The distribution system has 4 DG units which are connected to the grid through point of common coupling (PCC). 25 kV is the operating voltage at the DG units having a distance of 20 km with transmission lines of pi sections. The description of the components of the system which are taken from the appendix.

### Proposed Technique

The non-islanding and islanding voltage and current data are collected at a sampling rate of 1 kHz. Phasor estimation for the voltage and current is done by the least square method. The negative sequence voltage and current after the islanding are calculated from this information which are denoted as  $V_{2island}$  and  $I_{2island}$  respectively. Finally the absolute value of the angle ( $\varphi$ ) between negative sequence voltage and current after islanding is given as:

$$\varphi = \angle V_{2island} - \angle I_{2island} \quad (1)$$

Based on the value of this angle  $\varphi$  islanding is decided. The value of  $\varphi$  will be positive for the islanding and zero for non-islanding conditions. Fig. 2 gives the complete algorithm for the proposed technique.





## RESULTS

### ROCOF Technique and Its Performance

The islanding condition is simulated by opening the main circuit breaker (CB1) at  $t = 0.08$  s. DG-2 is tripped by opening the circuit breaker CB-DG2 with 60 % active power mismatch to have a non-islanding situation. The second one is simulated by opening a line section-2 (DL-2) with a 60% active power mismatch. At DG-1 and DG-2 terminals, the voltage and current data are stored at a sampling frequency of 1 kHz. The performance plot of conventional technique (ROCOF) with a 60% active power mismatch during islanding and first non islanding conditions is shown in Fig. 3. With a certain threshold value, the islanding condition is differentiated from non-islanding situations. The performance plot for islanding and non-islanding situations (section-2 cut off) is shown in Fig. 4, with 60% active power mismatch. It is found that during islanding the value of ROCOF may become zero and which may lead the non-islanding condition. The rate of change of frequency is affected with an active power mismatch. The active power mismatch is varied from 0% to 80% and the performance of ROCOF is verified. For higher active power mismatches higher will be the magnitude of ROCOF and with a proper threshold, it is easy to distinguish the islanding condition as the cases are shown in Figs. 3 and 4. The magnitude of ROCOF decreases for lower active power mismatch and falls below the threshold which becomes difficult to differentiate the two conditions. The performance plot for 5 % to 80 % active power imbalance is shown in Fig. 5. The islanding for 0 % active power mismatch is not detected because the value of the ROCOF will be less even the value may be zero.

### Performance Evaluation of Proposed Technique

In the proposed technique, the negative sequence component of voltage and current are calculated. For islanding condition the value of the angle between the two will be positive and will be zero for non-islanding conditions as the magnitudes of negative sequence components of voltage and current are more than for non-islanding condition (DG-2 tripping) which shown in Fig. 6. The islanding detection is obtained within 5 ms and dynamics of trip signal is consistent. Next islanding condition is simulated by tripping CB1 with 20% active power mismatch. The non-islanding condition is simulated with load switching at the PCC with a 20 % active power mismatch Performance of islanding relay located at DG-2 end is assessed with help of the proposed method. Corresponding performance plot for islanding and non-islanding conditions is shown in Fig. 7. It is quite clear from the figure that the absolute value of the angle during islanding is positive and zero for non-islanding condition. Hence the proposed technique identifies the islanding condition. Next the non islanding condition is simulated by taking out the section-2 completely with 0% active power mismatch.

The performance plot is shown in Fig. 8. Same conclusion can be made in this case also Power mismatch as low as 0%. The performance of the proposed islanding relay is evaluated during active power mismatch which is a vital concern to distributed generation system. Fig. 11 shows the performance of proposed technique for islanding detection at DG-4 end for active power mismatch of 0 and 80%. It is done by opening CB1 at  $t = 0.08$  s. It is found that the variation of the angle ( $\Phi$ ) is marginal as the active power changes from 0% to 80%. This is quite evident from the same figure as the trip signals for the two cases are almost the same. The performance curve of the islanding detector ( $\Phi$ ) is positive and there is almost no change in magnitude for both the cases. It is found that the magnitude of  $\Phi$  (angle between  $V_{2r}$  and  $I_{2r}$ ) is independent of variation in active power mismatch. One more important factor which determines the superiority of the technique is the response time, the time taken by the any method to respond from the occurrence of the event. Fig. 12 shows the response time for the proposed technique along with widely used technique ROCOF for the purpose of comparison. Response time for the ROCOF is higher than the proposed technique and also varies as the active power mismatch changes. However, as is evident from the figure, the response time for the proposed technique is quite low (around 5 ms) and is almost independent of the active power mismatch. The various results are shown in Table.1







## CONCLUSION

In this work a passive islanding detection technique is proposed. The performance of the conventional technique (ROCOF) also tested for different active power mismatch conditions. It is found that the conventional technique is dependent on active power mismatch. The proposed technique works well under a wide range of active power imbalance where the ROCOF fails. The response time of the proposed technique is around quarter cycle from the event's inception, showing fastness of the proposed algorithm compared to ROCOF relays. Another observation is the ability of the proposed technique to perform with active power imbalance of 0%, thus reducing the Non Detection Zone (NDZ) as compared to the existing ROCOF relays.

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**Satyanarayana and Radhika**

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**Table:1 Results for Islanding and Non islanding condition**

Event		Island current Phasor		Island voltage phasor		Angle Difference	Output
		Mag(A)	Angle(rad)	Mag(A)	Angle(rad)		
<b>Islanding</b>	0%	16.4	-3.07	192	-1.06	0.518	1
	30%	15.2	-2.82	408	-1.65	0.562	1
	60%	19.1	2.819	506	-1.29	0.656	1
	80%	46.9	-2.63	420	-1.62	0.693	1





Satyanarayana and Radhika							
<b>Non Islanding</b>	DL-2 cut off	0.3	2.297	5.6	0.662	0	0
	Load switching	0.3	1.21	12	0.976	0	0
	DL-2 tripping	1.2	2.028	9.8	-0.78	0	0
	Capicitor switching	2.06	1.897	21.5	0.0716	0	0

**Appendix**

Simulation parameters

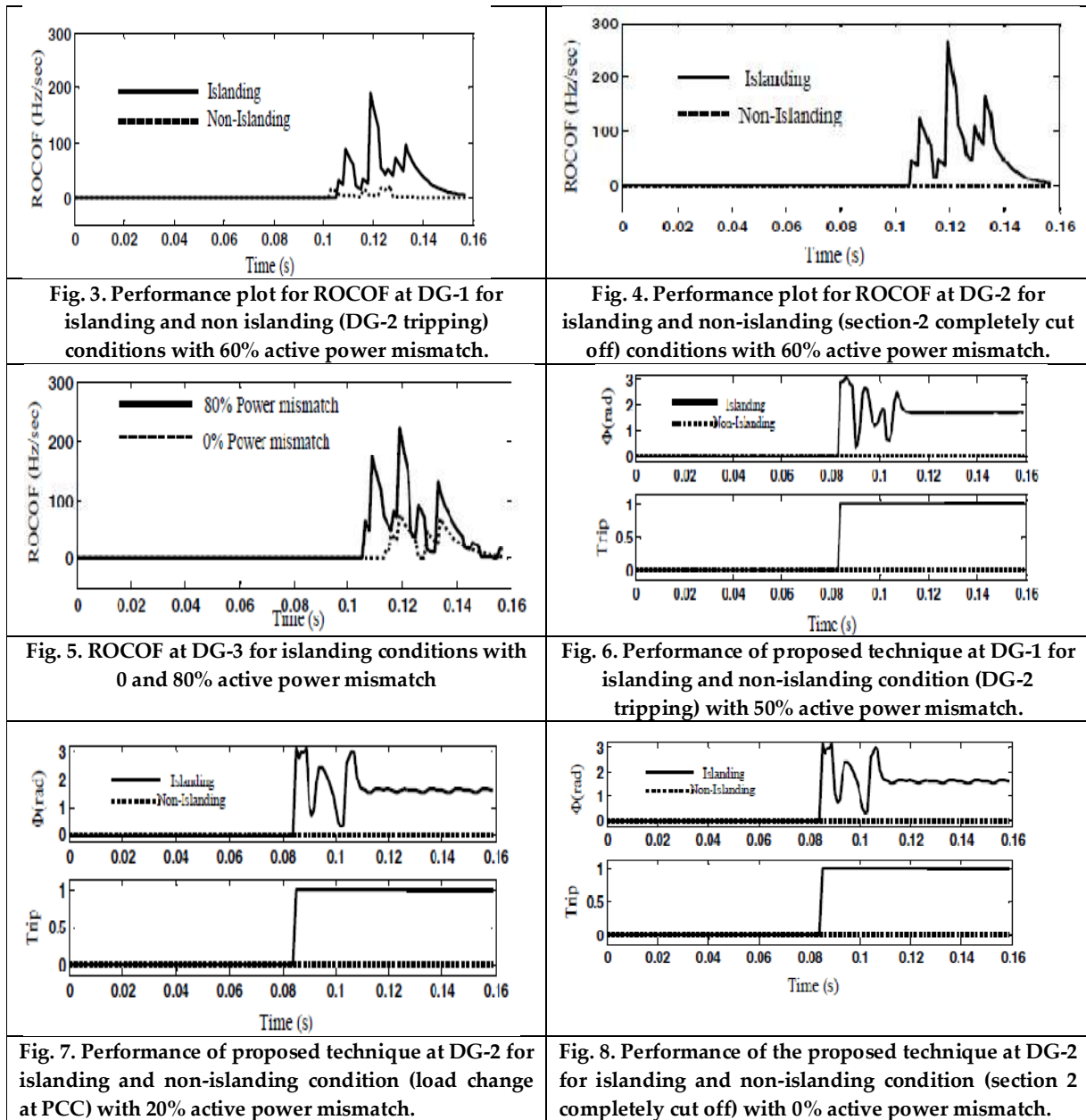
Name of the Parameter	Rating
Grid	Rated SC MVA= 1000, f= 50 Hz, kV = 120, Vbase = 120 kV.
Distributed Generators (DGs):DG-1, DG-2, DG-3	Wind farm (9 MW) consisting of six 1.5-MW wind turbines. The doubly-fed induction generator,(DFIG) has been considered for the proposed study
DG-4: Emergency Diesel Generator	5.0 MW, 400 V
Transformer TR-1:	Rated MVA = 50, f = 50 Hz, rated kV =, 120/25 kV, Vbase = 25 kV, R1 = .00375 pu, X1 = .1 pu, Rm = 500pu, Xm = 500 pu.
Transformer TR-2, TR-3, TR-4 and TR-5:	Rated MVA = 10, f = 50 Hz, rated kV = 575 V/25 kV (except TR-5: 400V/25 kV), Vbase = 25 kV, R1 = .00375 pu, X1 = .1 pu, Rm = 500 pu, Xm =500 pu.
Distribution lines (DL): DL-1, DL-2, DL-3, and DL-4:	PI-Section, 20 km each, rated kV = 25, rated MVA = 25, Vbase = 25 kV, R0 = 0.1153 Ω/km, R1 = 0.413 Ω/km, L0 = 1.05e-3 H/km, L1 = 3.32e-3 H/km, C0 = 11.33e-9 F/km, C1 =5.01e-09 F/km.
Normal loading data: L1	15 MW, 5 Mvar.
L2, L3, L4, L5	8 MW, 3 Mvar.

<b>Fig.1. Sample system studied for proposed technique.</b>	<b>Fig. 2. The flow diagram for proposed technique for islanding detection</b>





Satyanarayana and Radhika





Satyanarayana and Radhika

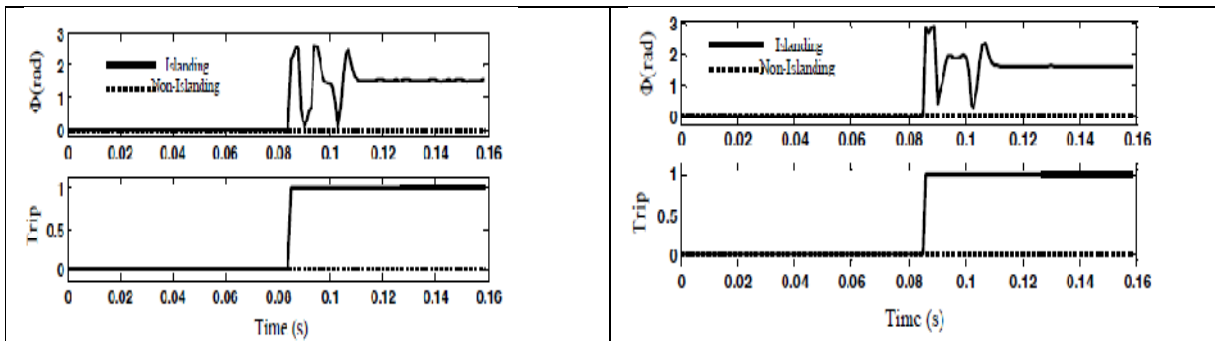


Fig. 9. Performance of the proposed technique at DG-3 for islanding and non-islanding condition (load switching at DG-3 end) with 5% active power mismatch.

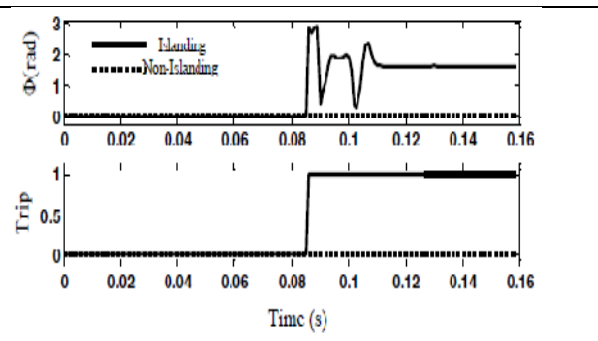


Fig. 10. Performance of proposed technique at DG-1 for islanding and non-islanding condition (capacitor bank switching at DG-1 end: harmonic distortion) with 5% active power mismatch.

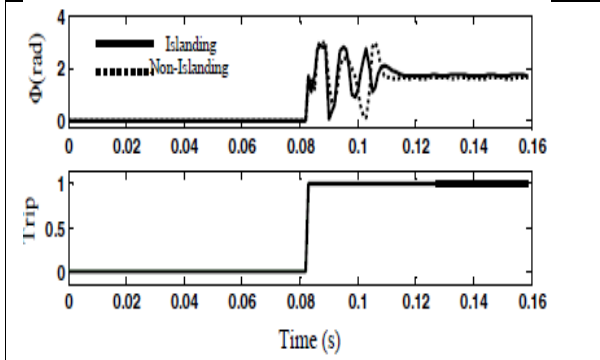


Fig. 10. Performance of proposed technique at DG-1 for islanding and non-islanding condition (capacitor bank switching at DG-1 end: harmonic distortion) with 5% active power mismatch.

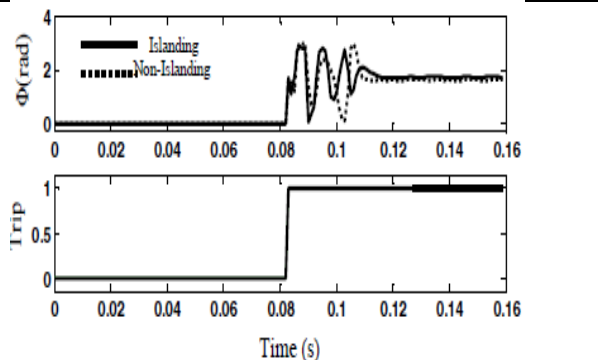


Fig. 11. Performance of proposed technique at DG-4 for islanding detection with 0 and 80% active power mismatch.

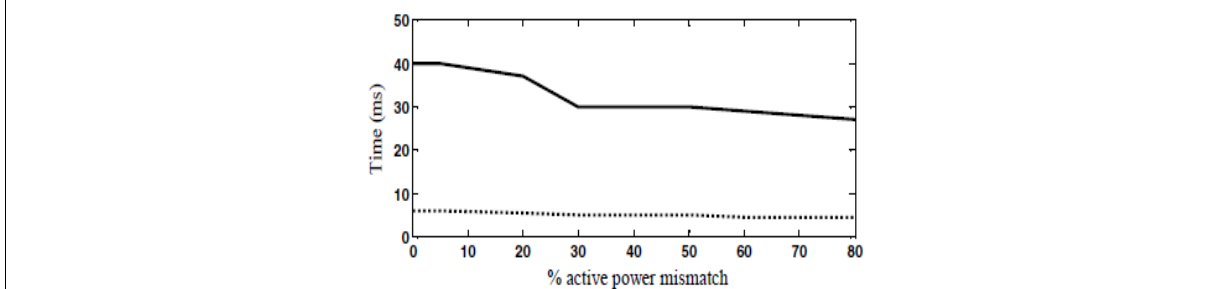


Fig.12. Active power mismatch vs operating time





## Pharmacological Review of *Epiphyllum oxypetalum* - Nishagandhi

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### ABSTRACT

In India, *Epiphyllum oxypetalum* is known as Brahmakamal or Nishagandhi. The plant can be grown nearby homes for religious purposes. *Epiphyllum oxypetalum* belongs to the Cactaceae family and is a unique plant with diverse traditional medicinal uses. This herb has been used to treat bloody phlegm and cough, uterine hemorrhage and shortness of breath. This descriptive review discusses distribution, botany, habitat, organoleptic and morphological characteristics, phytochemistry and pharmacological aspects, toxicity reports and future prospects of *Epiphyllum oxypetalum* plants. The plant contains phenols, proteins, amino acids, saponins, flavonoids, tannins, glycosides and resins. The plant has pharmacological activities such as anti-inflammatory, antibacterial, antimicrobial, analgesic, wound healing, antidiabetic, antioxidant, anticancer and anticorrosive properties. Few phytochemicals have been mentioned previously by other authors. The plant has not received much attention from researchers despite having several therapeutic properties. The current review includes the latest information obtained from all conceivable scientific sources that will be useful to future researchers for undertaking additional research on *Epiphyllum oxypetalum*.

**Key words:** *Epiphyllum oxypetalum*, Pharmacological aspects, Bloody phlegm and cough, Future prospects, Uterine haemorrhage, Therapeutic property





**Bhargav Patel et al.,**

## INTRODUCTION

Since recorded human history began, people have used plants for therapeutic purposes. In developing nations, traditional medicines primarily composed of medicinal herbs have historically been effective substitutes for modern pharmaceuticals. The use of herbal medicines and their components seems more common, especially among rural residents who live in poverty and lack access to healthcare. In contrast, there has been a significant rise in the demand for medicinal plants due to their chemical diversity and ability to create innovative therapeutic molecules to control a range of ailments. The use of medicinal plants as a form of therapy has persisted in the literature despite significant progress in discovering new synthetic medications. Consequently, studying medicinal plants has always been possible (Pan SY *et al.* 2014). *Epiphyllum oxypetalum* Haw (Fig. 1), often referred to as "Bakawali" and otherwise called "Bunga Raja" in Malaysia, is an effective herbal remedy in the Cactaceae family, and the genus, Cactus and is used in traditional Malay medicine. In addition to being grown frequently for ornamental purposes, people in rural areas also use the plant medicinally.

## DISTRIBUTION

Succulent *Epiphyllum oxypetalum* is among the most popularly grown species of the genus Cactaceae. It is a variant of the cereus with nocturnal blooms. Greek for "on the leaf," the genus *Epiphyllum* is composed of 19 species. They received their name because the blooms grow right on the leaves. They exist in Mexico, South America and Central America's rainforests. True cacti of the genus *Epiphyllum* are often referred to as "jungle cacti" or "epicacti" to note their differences from the closely comparable desert plants. In contrast to *Epiphyllum*, it has tiny spines covering it or little spines, and evenly distributed bumps on the stem are the origin of spines. Rather than protruding spines, the jungle cactus features leaf-like structures that resemble thicker stalks. The fibrous roots of epiphytic species grow in tiny rocks or climbing trees, holding onto decomposing plant materials. The Latin name *Oxypetalum* refers to the pointed shape of the petals. It was first discovered in Sri Lanka and is now spread throughout Southeast Asian nations, Brazil, Venezuela, Central America and North America. It is available in Bengaluru, Uttarakhand, Ranchi, Mumbai, and Chennai in India (Nyffeler R *et al.* 2010). One of the most well-known species in the genus *Epiphyllum* is a fast-growing member of the Cactaceae family. It is referred to as Bramhakalam in India and revered as a holy herb. It is prescribed for heart pain and is referred to as "Pain in the Heart" by the Shoshone Indian tribe. In addition to these names, it is often referred to as the Nishagandhi, Lady of Night, Queen of the Night, Dutchman's pipe cactus, etc. (Dandekar R *et al.* 2015).

## BOTANY AND TAXONOMY

Over 1870 recognized species in the 130 genera that constitute the Cactaceae family (Jyoti Kishen Kumar *et al.* 2015). The flattened parts of the plant give rise to flowers, that are 12 to 17 cm in width and 30 cm in length. True cacti of the genus *Epiphyllum* are sometimes referred to as "jungle cacti" or "epicacti" to distinguish them from strongly connected desert plants. *E. oxypetalum* serves many traditional therapeutic purposes and is a key component of Malay traditional medicine. The herb is frequently used to treat haemoptysis, menometrorrhagia, and dyspnoea in older people. Additionally, the components of *E. oxypetalum* are thought to have powerful pain-suppressing properties and the potential to prevent blood coagulation (Bhaskar V *Het al.* 2015).

## HABIT AND HABITAT

### HABITAT

Mainly grown in tropical forests and temperate forests.

## GROWTH TYPE

The perennial shrub is an epiphytic cactus with freely branching stems that can reach heights up to 6 meters in the wild.



**Bhargav Patel et al.,****ORGANOLEPTIC CHARACTERISTICS**

The leaves have a glabrous texture, a dark to light green colour, an astringent flavour, and a distinctive odour. The dried powder appears to be yellowish-brown (Sunaja Devi K R *et al.* 2018).

**CULTIVATION**

Despite being a cultivated species, the plant thrives in strong, indirect sunshine. Grow on sandy, somewhat acidic soil that is rich in detritus. It prefers soil that is wet but well-drained. During the summer, the plant was given regular watering. Rhizome, herbaceous stem, and leaf cuttings and layering are used to spread it. A leaf is buried in the ground or laid horizontally on the soil to grow the plant. We can also soak the chopped stalk in water. Adventitious roots appear after approximately three weeks and can be inserted into a soil-filled pot. From the phylloclade's edges, structures resembling bulbils sprout ([http://drichhapurak.webnode.com/news/epiphyllum\\_oxypetalum](http://drichhapurak.webnode.com/news/epiphyllum_oxypetalum) a unique and interesting plant brahmakamal night blooming cereus).

**MICROSCOPY**

The thick mesophyll tissue in the transverse section of the leaves is not divided into palisade and spongy tissue. Two to three layers of homogeneous cells make up the epidermis. The epidermis is mostly smooth, has few trichomes, and has paracytic and occasionally tricytic stomata. Mucilage and mucilage canals are present in the tissue of leaves. The midrib has an avascular bundle made up of the sclerenchyma sheath, phloem zone, and xylem arteries. In the centre of the vascular cylinder is pith tissue, consisting of giant cells with thin walls loaded with starch grains. Chlorophyll pigments are present in mesophyll cells close to the epidermis, while starch grains and crystals of the 500–750 micron-long cystolith are frequently found inside mesophyll cells. Some cells also contain a tiny crystal that resembles a rod. Several tiny and large mucilage channels can be found in the hypodermal zone. A 1.582 stomatal index was reported (Sunaja Devi K R *et al.* 2018).

**Pharmacognostic Characteristics**

The decorative plant *Epiphyllum oxypetalum* is regarded as being in high demand. It produces a massive, white blossom that only emerges once per night. It is known as night-blooming cereus as an outcome.

**MORPHOLOGICAL FEATURES****Stems**

Flattened stems are made up of fleshy wings with a scalloped edge surrounding a thick, round midrib. The stems are upright, branching, and ascending. The bases of primary stems are ligneous, terete, and up to 6 meters long. They have been flattened recently. Secondary stems are flat, many branching, dark green elliptic, acuminate, and up to 15-50x5-12 cm in length (<http://florafaunaweb.nparks.gov.sg>).

**FOLIAGE**

These species produce no leaves. Instead, they produce altered stems that resemble leaves and have similar purposes.

**FLOWERS**

Star-shaped, fragrant flowers are nocturnal, approximately 28 cm long, and 13 cm broad. They have 25–30 white, linear petals (<http://www.Indianbotanists.com>: *Epiphyllum oxypetalum* (brahmakamal): Orchid Cactus- An interesting plant). The distinctive smell is produced by benzyl salicylate. The pericarpels are bare, green, and slightly inclined. Short and thin bracteoles are present. The base is green, 4–9 mm in diameter, and arched. Receptacles can reach a height of 13–18 cm. The outer petals are 8–10 cm long, linear, sharp, and reddish to amber. Up to 8-10 cm long and 2-5 cm wide, the inner petals are pale, oblanceolate, oblong, and acuminate. Slender, white or greenish-white stamens. The centre of the bloom has a complex white stigma that sticks out. Styles have several lobes, are 4 mm thick, and are greenish-white, pale yellow, or white. They are also as long as the inner tepals ([http://drichhapurak.webnode.com/news/epiphyllum\\_oxypetalum](http://drichhapurak.webnode.com/news/epiphyllum_oxypetalum) a unique and interesting plant brahmakamal night blooming cereus). Flowering does not happen very often. Flower buds are at the end of stems that have been



**Bhargav Patel et al.,**

manipulated to resemble leaves. For several hours, they swell somewhat before flowering later that night (<http://florafaunaweb.nparks.gov.sg>).

**FLOWERING SEASON**

June-October

**FRUITS**

Fruits appear rare, and are purplish red in colour, oblong, 16x5.7 cm, and seeds 2-2.5x1.5 mm (Sunaja Devi K R *et al.* 2018)

**TAXONOMIC CLASSIFICATION****Table 1 Taxonomy of *Epiphyllum oxypetalum*****SYNONYMS**

*Epiphyllum aacuminatum*, *Cereus oxypetalus*, *Epiphyllum grande*, *Cactus oxypetalus*, *Cereus latifrons*, *Phyllocactus oxypetalus*, *Cactus oxypetalus* ([www.theplantlist.org/tpl1.1/record/kew2791457](http://www.theplantlist.org/tpl1.1/record/kew2791457)).

**COMMON NAMES**

Dutch man's pipe, night blooming cereus, Nishagandhi, Queen of Night, Lady of Night, Dutchman's pipe Cactus, Broadleaf *Epiphyllum*, Orchid cactus, Jungle cactus (<http://florafaunaweb.nparks.gov.sg>).

**VERNACULAR NAMES****India:** Gul-E-Bakawali, Nishagandhi, Brahmakamal, Bakawali**French:** Reine De La Nuit**Japanese:** Gekka Bijin**Indonesia:** Wijaya Kusuma**German:** koniger Der Nacht**Chinese:** Yue Xia Mei Ren, Jin Gou Lian, Qiong Hua, Tan-Hua**Malaysia:** Bunga Bakawali**TRADITIONAL USES**

*E. oxypetalum* serves various traditional purposes and is a key component of Malay herbal medicine. The herb is frequently used to treat haemoptysis, menometrorrhagia, and dyspnoea in older peoples. Additionally, the components of *E. oxypetalum* are thought to have powerful pain-suppressing properties and the potential to prevent blood coagulation (Dandekar R *et al.* 2015). According to reports, the stems can treat dropsy and heart problems. Vietnamese people make soups with the petals of withered flowers, which are thought to have tonic and aphrodisiac effects. Flowers are also utilized to treat wound abscesses to promote rapid healing.

**PHYTOCHEMISTRY**

A key factor in the development of therapeutic plants is safety. Through GC-MS analysis of the methanolic extract of the *Epiphyllum oxypetalum* leaves, 11 chemicals were identified. Their toxicity was assessed using QSAR's toxicity estimation software tool (TEST). Phytoconstituents found in an alcohol extract of *Epiphyllum oxypetalum* leaves dissolved in a mixture of solvent by GC-MS analysis: Heptacosane, Nonadecane, 2-methyl-, Spinasterone, 4,22-Stigmadiene3-one, Tetracosane, Hentriacontane, Stigmast-4-en-3-one, Testosterone cypionate. Phytoconstituents found in alcohol extract of *Epiphyllum oxypetalum* leaves by GC-MS analysis: 4-Hydroxy-2-methylcetophenone, Megastigmatrienone, 4-((1E)-3-Hydroxy-1-propenyl)-2-methoxy phenol, n-Hexadecanoic acid, Octadecanoic acid, Phytol, Cholesta-22,24-dien-5-ol, 4,4-dimethyl, 6-octen-1-ol, 3,7-dimethyl-, stigmasterol, 22-Stigmasten-3-one (Jyoti Kishen Kumar *et al.* 2015).



**Bhargav Patel et al.,****BIOACTIVITY****ANTI- INFLAMMATORY ACTION**

The anti-inflammatory activities of aqueous and alcohol extracts of the leaves of *Epiphyllum oxypetalum* were reported. Models used during the investigation included both in vitro and in vivo procedures. Human red blood cell membrane stabilization and protein denaturation inhibition techniques were used in the in vitro models. Albino rats were used to test the in vivo anti-inflammatory efficacy utilizing a carrageenan-induced paw oedema model. The extracts were evaluated at 200 and 400 mg/kg, and p.o aspirin (10 mg/kg, p.o) was used as the reference drug for comparison purposes. The study's results indicated the significant anti-inflammatory effects of the test extracts in a dose-dependent manner, with the observation that aqueous leaf extracts demonstrated greater activity than alcohol extracts (Dandekar R *et al.* 2015).

**ANTIOXIDANT ACTION**

The in vitro antioxidant activities of *Epiphyllum oxypetalum* were reported. Using the DPPH assay method and hydrogen peroxide scavenging, the alcohol and aqueous extracts of dried *Epiphyllum oxypetalum* leaves were assessed for their capacity to neutralize free radicals. The maximum free radical scavenging activity using the DPPH technique was determined to be (60.37±1.67), as opposed to the aqueous extract (34.23±0.88). Aqueous extract and alcohol both showed the highest percentage of inhibition at 2000 g/ml. In the hydrogen peroxide scavenging method, the greatest inhibition by the alcohol extract (43.76±0.97) and aqueous extract (27.07±0.16) was demonstrated at a 500 g/ml concentration. Ascorbic acid serves as the standard reference for both techniques (Fegade Bet *al.* 2015).

**ANTIMICROBIAL ACTION**

At various concentrations of 25, 50, 75, and 100 mg/ml, the antimicrobial activity of petroleum ether, ethanol, and acetone extracts of the leaves against *Aspergillus niger*, *Rhizopus oryzae*, *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *Klebsiella pneumoniae*, *Aspergillus oryzae*, and *Aspergillus terreus* was reported. The study showed positive antibacterial activity against all test species, except for the test fungi *A. terreus*, *A. niger* and *R. oryzae*. The leaves contained phenolic chemicals, glycosides, saponins, steroids, terpenoids, tannins, and resins, according to a preliminary phytochemical examination of the extracts (Upendra R S *et al.* 2012).

**NANOPARTICLE BIOSYNTHESIS AND ANTIBACTERIAL ACTION**

The antibacterial activities of silver nanoparticles biosynthesized from the aqueous leaf extract of *Epiphyllum oxypetalum* against *Klebsiella pneumoniae*, *Propionibacterium acne*, and *Pseudomonas aeruginosa*, were determined by the disc diffusion method. The study's findings showed that the produced AgNP's had significant bactericidal action against the test organisms. When used alongside other antibiotics to treat test organisms, the effectiveness of silver nanoparticles was significantly enhanced (Paralika P. 2014).

**ANALGESIC ACTION**

The analgesic activity of the ethanolic leaf extract of *E. oxypetalum* on Eddy's hot plate method was reported. The thermal test was chosen for this investigation due to its many benefits, including its sensitivity to potent analgesics and minimal tissue damage. One of the best approaches for examining the role of centrally-acting analgesics is Eddy's hot plate method, which utilizes spinal reflexes. Medicines that predominantly affect the central nervous system block both phases equally, whereas drugs with peripheral effects block the late phase. In the heat conduction method, an increase in reaction time is typically seen as a crucial indicator of analgesic activity. In this paradigm, the animals' increased ability to tolerate stress suggests that a higher centre may be involved. Therefore, it is believed that the analgesic effect of *Swertia chirayita* shown in this study may include the main activity. The latency period of the ethanolic extract was considerably better ( $P < 0.05$ ) than that of the control at the time interval of 30 - 60 minutes, whereas the latency period of the standard was more significant ( $P < 0.05$ ) than that of the test medication at all time intervals of the experiment (Hemasoundarya P *et al.* 2019).



**Bhargav Patel et al.,****ANTICANCER ACTION**

In the present study, *Epiphyllum oxypetalum* (DC.) The 100% ethanolic extract was screened for anticancer activity using the in-vivo technique using a colon cancer model that had been generated by N-methyl nitrosourea at doses of 100 mg/kg (Test-I) and 200 mg/kg (Test-II). The NMU-bearing rats displayed abnormal crypt foci, following earlier research using the NMU-induced paradigm (ACF). The available data support the hypothesis that abnormal crypt foci are colon cancer precursors whose size and number closely correspond with the likelihood of developing colon cancer. In the current investigation, animals were given NMU by intrarectal instillation, and changes in body weight percentage, antioxidant status, tumourourological parameters, and colon histology were all noted (Shraddha Anil Naik *et al.* 2021).

**WOUND HEALING PROPERTY**

In the present study, *E. oxypetalum* (DC.) leaf extract's wound-healing capabilities in streptozotocin-induced diabetic mice administered topically. The groups treated with 10% and 20% *Epiphyllum oxypetalum* extract showed significant wound healing compared to the diabetic control group. The best activity was shown by the *E.oxypetalum* 20 group, which was comparable to that of the non-diabetic control group. From the results above, it can be concluded that topical application of 96% ethanol extract of *Epiphyllum oxypetalum* leaves could accelerate the wound healing process in diabetics (Lusi Putri Dwita *et al.* 2019).

**ANTICORROSIVE ACTION**

Using gravimetric and electrochemical impedance spectroscopy, it was determined how the environmentally delicate leaf extract of *Epiphyllum oxypetalum* affected the corrosion of aluminum alloy AA5052 in a 0.5 M HCl environment. Based on the introduction of various concentrations of *E. oxypetalum* leaf extract in 0.5 M HCl solution, which was added to the corrosive media, which decreased the weight loss and corrosion rate of the AA5052 alloy. The observation that  $E_a$  increased when inhibition was added shows that the inhibitor molecules successfully adsorbed to the metal surface, creating a double layer. Entropy decreases after adding the inhibitor extract, which causes the inhibitor molecules to associate and interact. The adsorption heat proves that adsorption occurred at the metal/solution interface. According to the electrochemical impedance spectroscopy approach, the charge transfer resistance rises as the concentration of inhibitors increases. The green inhibitor's ability to inhibit cells becomes less effective as the temperature rises but becomes more effective as the inhibitor concentration rises. Langmuir's adsorption isotherm is followed by the *Epiphyllum oxypetalum* adsorption isotherm on the AA5052 surface. Adsorption was accomplished physically. The inhibition process followed first order reaction kinetics. According to Gibb's free energy, the process was spontaneous. The adsorption of the inhibitor molecules from the metal surface protected the ingot's mechanical hardness strength. The surface, as shown by surface morphology, protected the metal surface from damage (Francis Okechukwu Nwosu. 2020).

**ANTIHYPERURICEMIA**

The enzymatic approach using the uric acid reagent FS-TBHBA(2,4,6-tribromo-3-hydroxybenzoic acid) was used to measure the levels of uric acid. The mechanism behind this approach is that the enzyme uricase oxidizes uric acid to produce allantoin,  $H_2O_2$  and  $CO_2$  with the support of oxygen and water. The peroxidase enzyme catalyses the reaction, which results in the formation of pink quinonimine from the  $H_2O_2$  that is produced (Artini N P R *et al.* 2012). Flavonoids are substances that contribute to decreasing uric acid levels. The action of xanthine oxidase and superoxidase is inhibited by the flavonoid group of chemicals, which lowers the production of uric acid (Sonia R *et al.* 2020).

**ANTIDIABETIC**

The antidiabetic activity of *Epiphyllum oxypetalum* methanolic leaf extract exhibited an inhibitory effect on  $\alpha$ -amylase. Basically  $\alpha$ -amylase is used as a hypoglycaemic agent to control glucose levels, mainly in diabetes mellitus-2 patients. The  $\alpha$ -amylase enzyme slows down the breakdown of carbohydrates and extends the time it takes them to be absorbed, which lowers the rate of glucose absorption and in turn, lowers the postprandial rise in plasma





**Bhargav Patel et al.,**

glucose (Momina S Set al. 2020). Some secondary metabolites such as flavonoids, phenolics, alkaloids and steroids have been proven to be antidiabetic (Ebrahimi E et al. 2017).

**TOXICITY STUDY**

For this particular study, refer to OECD guideline number 425. As a reference for acute oral toxicity. Female Wistar albino rats were obtained and housed for acclimation and fasted overnight. The dose of an absolute ethanolic extract of leaves of the *Epiphyllum oxypetalum* plant was determined based on the weight of Wistar rats. A dose of 2000 mg/kg was administered to 3 female Wistar rats in accordance with OECD recommendations. The animals were monitored for changes in consciousness, mood, CNS activity, muscular tone, reflexes and autonomic profile throughout the course of 4, 8, 12 and 24 hours. Additionally, the animals were monitored for 15 days to look for any abnormalities. According to this study *Epiphyllum oxypetalum* leaves are safe for people and may one day be used to make new treatments (Narisawa T et al. 1998)

**FUTURE PROSPECTS**

Based on the information provided, the *Epiphyllum oxypetalum* plant has the capability to be developed into a source of medicinal ingredients in the future. To treat a variety of ailments, it can therefore be utilized as a raw material for natural medicine. Chemicals in the form of primary and secondary metabolites can be found in the plant's bloom and leaves. The steroid compounds testosterone cypionate, stigmaterol and other chemicals are found to predominate among the chemical components found in this plant. In the *Epiphyllum oxypetalum* plant, there are no identified chemical components that are active against specific pharmacological activities. These isolates will provide quality criteria for the development of extracts or fractions. Investigating the plant's roots will be necessary in the future to complete the description of the plant. *Epiphyllum oxypetalum* has the potential to operate as an anti-inflammatory, antioxidant and antibacterial agent due to its pharmacological activity. Research must be done on the chemical substances found in this plant, especially steroids, to determine whether they can be used for other medicinal applications such as hormone treatment for infertility, contraception or even aphrodisiacs.

**CONCLUSION**

According to the literature review, *E. oxypetalum* is a significant herbal plant that can be used to cure several ailments. The presence of several chemical components in plants is what gives them their wide range of therapeutic and pharmacological effects. Although the plant is among the underutilized resources in tropical regions, its therapeutic uses have not yet been investigated, and we can anticipate an excellent result in the future.

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Bhargav Patel et al.,

Table 1 Taxonomy of *Epiphyllum oxypetalum*

KINGDOM	PLANTAE
SUBKINGDOM	Tracheobionta
SUPER-DIVISION	Spermatophyta
DIVISION	Magnoliophyta
CLASS	Magnoliopsida
SUPERORDER	Caryophyllanae
ORDER	Caryophyllales
FAMILY	Cactaceae
GENUS	<i>Epiphyllum</i>
SPECIES	<i>E. oxypetalum</i>
BINOMIAL NAME	<i>Epiphyllum oxypetalum</i>



Fig 1; *Epiphyllum oxypetalum* whole plant





## RESEARCH ARTICLE

## On The Integral Solutions of System of Diophantine Equations $m \pm D = u^2$ and $\frac{m}{D} \mp (D \pm S) = v^2$ for the Analysis of Square Numbers of Some Specific Algebraic Forms

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### ABSTRACT

This paper investigates the solvability and the representation of the solutions the system of Diophantine equations  $m \pm D = u^2$  and  $\frac{m}{D} \mp (D \pm S) = v^2$  in order to analyze the number patterns of some specific algebraic form. A case for non – square value of D studied in this work in detail particularly. Several illustrations show the existence of the numbers with certain algebraic form through solving the system considered in this study.

**Keywords:** system of equations, pell's equation, integral solutions

### INTRODUCTION

The number 62 has the specific character that if the number 2 is added to this number, then its sum is a perfect square, 64 and if the number 2 with addition of 20 is subtracted from to the number 62 divided by the same number





### Hari Ganesh and Mahalakshmi

2, the result is also a perfect square, 9. Its algebraic structures are explicitly represented as  $62 = 8^2 - 2$  and  $62 = 2(3^2 + (2 + 20))$ . There are infinitely many integers having these two different algebraic patterns.

For example,

$$1294 = 36^2 - 2 \quad \& \quad 1294 = 2(25^2 + (2 + 20))$$

$$43262 = 208^2 - 2 \quad \& \quad 43262 = 2(147^2 + (2 + 20))$$

etc.....

In order to identify the integers having this type of algebraic patterns, the non-zero integers  $m$  and  $S$  are obtained from the system of Diophantine equations of order two  $m + D = u^2, \frac{m}{D} - (D + S) = v^2$  arrived from the algebraic patterns. Subsequently, we have arrived three more systems of Diophantine equations  $m + D = u^2, \frac{m}{D} - (D - S) = v^2$ ,  $m - D = u^2, \frac{m}{D} + (D \pm S) = v^2$  from the following algebraic structures of the integers respectively.

$$62 = 8^2 - 2 \quad \& \quad 62 = 2(6^2 + (2 - 7))$$

$$2302 = 48^2 - 2 \quad \& \quad 2302 = 2(34^2 + (2 - 7))$$

$$12 = 3^2 + 3 \quad \& \quad 12 = 3(3^2 - (3 + 2))$$

$$228 = 15^2 + 3 \quad \& \quad 228 = 2(9^2 - (3 + 2))$$

$$30 = 5^2 + 5 \quad \& \quad 30 = 5(2^2 - (5 - 7))$$

$$7230 = 85^2 + 5 \quad \& \quad 7230 = 5(38^2 - (5 - 7))$$

The above algebraic patterns of numbers can be obtained through finding infinitely many integer solutions of the system of Diophantine equations  $m \pm D = u^2, \frac{m}{D} \mp (D \pm S) = v^2$ . So the analysis has to be made for the existence

of infinitely many integer solutions of the system of double Diophantine equations considered in this study. In order to find many integer solutions of such type of system of Diophantine equations has been investigated in many research articles.

In 1953, Mills studied a pair of simultaneous quadratic Diophantine equations to solve easily and completely by difference equation methods. In 1990, Jean - Francois Romeuf presented an algorithm to compute a minimal length solution of a system of two Diophantine equations. Subsequently he introduced one more algorithm to compute a rational expression of all the solutions of the system in the same paper. In 1995, Siegel-Baker method was used to find all the integral solutions of the system of Diophantine equations  $x^2 - 6y^2 = -5$  and  $x = 2z^2 - 1$  by Mignotte and Petho. In 1998, Kiran presented a general elementary approach to solve the system of Diophantine equations  $x^2 - ay^2 = b$ ,  $P(x, y) = z^2$  and some specific cases  $P(x, y) = cy^2 + d$  and  $P(x, y) = cx + d$  based on an idea of Cohn and the theory of the Pell equation. In 2004, Maohua Le gave an elementary method to find all positive integer solutions of the system of equations  $x^2 - Dy^2 = 1 - D$  and  $x = 2z^2 - 1$ . In 2013, Oscar Pérez, *et al.* proposed a method of optimization to find the numerical solution of some non-linear systems of Diophantine equations including some exponential cases. Subsequently in the same year, Ajai and Jaros obtained a parametric solution of the Quintic Diophantine equation  $ab(a+b)(a^2+ab+b^2) = cd(c+d)(c^2+cd+d^2)$  in order to find the parametric solutions of two Diophantine systems concerning fifth powers. Silan Zhang *et al.* introduced a generalized method to solve the family of Diophantine equation  $x^2 - 6y^2 = -5$  and  $x = az^2 - b$  completely in 2014. In 2015, Takafumi Miyazaki and Florian Luca created a positive integer solution to the first equation





**Hari Ganesh and Mahalakshmi**

$(m^2 - 1)^r + b^2 = c^2$  of the system for given positive integers  $r$  and  $m$ . Moreover, they showed that there are only finitely many pairs  $(r, m)$  with  $r \equiv 2 \pmod{4}$  and  $m$  even such that the second equation of the system holds for some triple  $(x, y, z)$  of positive integers with  $(x, y, z) \neq (r, 2, 2)$ . In 2019, Gopalan *et al.* determined sets of non-zero distinct integer solutions to the system of double equations  $x + y^2 = a^2, x - y^2 = b^2$  with some interesting properties among the solutions. Subsequently in 2021 Gopalan *et al.* analysed the system of double equations  $d + ay + bx + cx^2 = z^2$  and  $y + z = x^2$  to find its infinitely many non-zero distinct integer solutions with the help of Pellian equation. In this way, we have made an attempt to find infinitely many positive integer solutions of the proposed system of Diophantine equations  $m \pm D = u^2, \frac{m}{D} \mp (D \pm S) = v^2$  for the analysis the number patterns of some specific algebraic forms.

**Method of Identifying the Number of some Specific Algebraic Forms**

The system Diophantine Equations for the analysis of number patters of some specific algebraic forms taken in this work to be solved as follows:

**Type I System of Diophantine Equations**

First we consider the following equation to find its integers solutions in order to identify the numbers of some specific algebraic form as follows:

$$m + D = u^2 \tag{1}$$

$$\frac{m}{D} - (D \pm S) = v^2 \tag{2}$$

Eliminating  $m$  from the equations (1) and (2), we obtain the following equations of Pellian form

$$u^2 - Dv^2 = D^2 + DS + D \tag{3}$$

$$u^2 - Dv^2 = D^2 - DS + D \tag{4}$$

**Type II System of Diophantine Equations**

Now we consider the other system of Diophantine equations for the analysis of algebraic patterns of numbers as follows:

$$m - D = u^2 \tag{6}$$

$$\frac{m}{D} + (D \pm S) = v^2 \tag{7}$$

Eliminating  $m$  from (6) and (7), we get the equations of following Pellianform

$$u^2 - Dv^2 = -(D^2 + DS + D) \tag{8}$$

$$u^2 - Dv^2 = -(D^2 - DS + D) \tag{9}$$

where  $m, S$  and  $D$  are positive integers and  $D$  is a square free number

Using [2], we get the general solution  $(u_n, v_n)$  of the Pellian Equations (3), (4), (8)& (9) as follows:





**Hari Ganesh and Mahalakshmi**

$$u_n = \frac{1}{2} \left[ (U_0 + \sqrt{D} V_0)^n (u_0 + \sqrt{D} v_0) + (U_0 - \sqrt{D} V_0)^n (u_0 - \sqrt{D} v_0) \right] \dots\dots\dots(7)$$

$$v_n = \frac{1}{2\sqrt{D}} \left[ (U_0 + \sqrt{D} V_0)^{n+1} (u_0 + \sqrt{D} v_0) - (U_0 - \sqrt{D} V_0)^{n+1} (u_0 - \sqrt{D} v_0) \right] \dots\dots\dots(8)$$

$n = 0, 1, 2, \dots\dots\dots$

where  $u_0 + \sqrt{D} v_0$  is the fundamental solution of (3), (4), (8) & (9) and  $U_0 + \sqrt{D} V_0$  is the fundamental solutions of  $u^2 - Dv^2 = 1$ .

Using the general solutions  $(u_n, v_n)$  of equations(3), (4), (8) & (9), we can find the sequence of values of  $m$  for  $n = 1, 2, 3, \dots\dots\dots$

The values of  $m$  can be obtained with the help of following formulae for type I & type II system of Diophantine equations obtained from (1)& (2) and (6)& (7) respectively.

$$m = \left\{ \frac{1}{2} \left[ (U_0 + \sqrt{D} V_0)^n (u_0 + \sqrt{D} v_0) + (U_0 - \sqrt{D} V_0)^n (u_0 - \sqrt{D} v_0) \right] \right\}^2 - D \dots\dots\dots(9)$$

$$m = \left\{ \frac{1}{2} \left[ (U_0 + \sqrt{D} V_0)^n (u_0 + \sqrt{D} v_0) + (U_0 - \sqrt{D} V_0)^n (u_0 - \sqrt{D} v_0) \right] \right\}^2 + D \dots\dots\dots(10)$$

$n = 1, 2, 3, \dots\dots\dots$

**Numerical illustrations**

**Numerical Illustrations for Type I System of Diophantine Equations  $m + D = u^2, \frac{m}{D} - (D + S) = v^2$**

**For  $D = 2$**

To determine the nature of solutions, one has to go for particular values of  $D$  and  $S$ . It is seen that  $D = 2$ , the equation is solvable when  $S = f(s) = s^2 + 4s - 1, s^2 + 6s - 2, 4s^2 + 4s - 2, 2s^2 + 8s + 5$

Substituting  $D = 2$  and  $S = f(s) = s^2 + 4s - 1, s^2 + 6s - 2, 4s^2 + 4s - 2, 2s^2 + 8s + 5$  in (3) and employing solutions of the Pell's equation  $u^2 - 2v^2 = 1$  the sequence of values of  $m$  are found to be

$$m(n, s) = \left\{ \frac{1}{2} \left[ (3 + 2\sqrt{2})^n (u_0 + v_0\sqrt{2}) + (3 - 2\sqrt{2})^n (u_0 - v_0\sqrt{2}) \right] \right\}^2 - 2$$

$n = 0, 1, 2, \dots\dots\dots$

where  $u_0 + \sqrt{2}v_0 = 2(s + 1) + s\sqrt{2}, u_0 + \sqrt{2}v_0 = (2s + 10) + (s + 7)\sqrt{2},$

$u_0 + \sqrt{2}v_0 = (4s + 2) + (2s + 1)\sqrt{2}, u_0 + \sqrt{2}v_0 = (6s + 12) + (4s + 8)\sqrt{2},$  are the fundamental solutions of  $u^2 - 2v^2 = 2(s^2 + 4s - 1) + 6, u^2 - 2v^2 = 2(s^2 + 6s - 2) + 6, u^2 - 2v^2 = 2(4s^2 + 4s - 2) + 6$  and  $u^2 - 2v^2 = 2(2s^2 + 8s + 5) + 6$  respectively.

For the sake of simplicity a few solution of are presented in the following Tables

It is interesting to note that all the solutions obtained for  $f(s) = s^2 + 4s - 1$  and  $f(s) = s^2 + 6s - 2$  are even. When  $S = 4, 11, 20$  and  $S = 5, 14, 25$  the last digits of the solutions presented in Table 1are of the following patterns respectively:

4	4	2;	4	4	8;	2	4	2
4	2	2;	4	2	4;	2	2	4







**Hari Ganesh and Mahalakshmi**

It is interesting to note that all the solutions obtained for  $f(s) = 4s^2 + 4s - 2$ ,  $f(s) = 2s^2 + 9s + 2$  and  $f(s) = 2s^2 + 8s + 5$  are even. When  $S = 6, 22, 46$ ,  $S = 13, 28, 47$  and  $S = 15, 29, 47$  the last digits of the solutions presented in Table 2 are of the following patterns respectively:

4	8	4;	8	8	8;	8	4	4
2	8	2;	2	2	8;	8	8	8
4	2	2;	2	4	4;	8	8	8

Further the solutions satisfy the following recurrence relations:

(a) Recurrence relations for solution  $m(n, s)$  among different values of  $s$  :

(i)  $[m(n, s + 2) + D]^{1/2} - 2[m(n, s + 1) + D]^{1/2} + [m(n, s) + D]^{1/2} = 0$

where  $f(s) = s^2 + 4s - 1, s^2 + 6s - 2, 2s^2 + 8s + 5$

(ii)  $5[m(n, s + 2) + D]^{1/2} - 8[m(n, s + 1) + D]^{1/2} + 5[m(n, s) + D]^{1/2} + 8 \sum_{i=0}^{n-1} [m(i, s + 1) + D]^{1/2} = 0$

where  $f(s) = 4s^2 + 4s - 2$

(b) Recurrence relations for solution  $m(n, s)$  among different values of  $n$  :

(iii)  $[m(n, s) + D]^{1/2} - 6[m(n + 1, s) + D]^{1/2} + [m(n + 2, s) + D]^{1/2} = 0$

where  $f(s) = s^2 + 4s - 1, s^2 + 6s - 2, 4s^2 + 4s - 2, 2s^2 + 8s + 5$

**3.2. Numerical Illustrations for Type I System of Diophantine Equations  $m + D = u^2, \frac{m}{D} - (D - S) = v^2$**

**For  $D = 3$**

To determine the nature of solutions, one has to go for particular values of  $D$  and  $S$ . It is seen that  $D = 3$ , the equation is solvable when  $S = f(s) = s^2 + 4s - 4, s^2 + 8s - 7, s^2 + 2s + 2, s^2 + 6s + 13$ .

Substituting  $D = 3$  and  $S = f(s) = s^2 + 4s - 4, s^2 + 8s - 7, s^2 + 2s + 2, s^2 + 6s + 13$ . in (4) and employing solutions of the Pell's equation  $u^2 - 3v^2 = 1$  the sequence of values of  $m$  are found to be

$$m(n, s) = \left\{ \frac{1}{2} \left[ (2 + \sqrt{3})^n (u_0 + v_0 \sqrt{3}) + (2 - \sqrt{3})^n (u_0 - v_0 \sqrt{3}) \right] \right\}^2 - 3$$

$n = 0, 1, 2, \dots$

where  $u_0 + \sqrt{3}v_0 = 6 + (s + 2)\sqrt{3}$  or  $(3s + 18) + (2s + 10)\sqrt{3}$ ,  $u_0 + \sqrt{3}v_0 = 9 + (s + 4)\sqrt{3}$  or

$(3s + 30) + (2s + 17)\sqrt{3}$   $u_0 + \sqrt{3}v_0 = 3 + (s + 1)\sqrt{3}$  or  $(3s + 9) + (2s + 5)\sqrt{3}$

$u_0 + \sqrt{3}v_0 = 0 + (s + 3)\sqrt{3}$  or  $(3s + 9) + (2s + 6)\sqrt{3}$  are the fundamental solutions of

$u^2 - 3v^2 = -3(s^2 + 4s - 4) + 12$ ,  $u^2 - 3v^2 = -3(s^2 + 8s - 7) + 12$ ,  $u^2 - 3v^2 = -3(s^2 + 2s + 2) + 12$ , and

$u^2 - 3v^2 = -3(s^2 + 6s + 13) + 12$ , respectively.

For the sake of simplicity a few solution of are presented in the following Tables

It is interesting to note that all the solutions obtained for  $f(s) = s^2 + 4s - 4$  are even and odd for odd values of  $s$  and even and odd values of  $n$  respectively and the solutions for  $f(s) = s^2 + 8s - 7$  are even for odd values of  $s$  and even and odd for even values of  $s$  and even and odd values of  $n$  respectively. When  $S = 1, 8, 17$  and  $S = 2, 13, 26$  the last digits of the solutions presented in Table3 are of the following patterns respectively:

6	3	8	1	8	3;	3	3	7;
6	1	8	1	6	3			





**Hari Ganesh and Mahalakshmi**

6 8 6; 8 3 2 3 8 7; 6 8 8

It is interesting to note that all the solutions obtained for  $f(s) = s^2 + 2s + 2$  are even and odd for odd values of  $s$  and even and odd values of  $n$  respectively and the solutions for  $f(s) = s^2 + 6s + 13$  are odd for odd values of  $s$  and even and odd for even values of  $s$  and even and odd values of  $n$  respectively. When  $S = 5, 10, 17$  and  $S = 20, 29, 40$  the last digits of the solutions presented in Table 4 are of the following patterns respectively:

6 1 2 1 6 7; 6 2 6;  
 6 1 8 1 6 3  
 1 1 7; 2 7 2 7 2 7; 1 1 7

Further the solutions satisfy the following recurrence relations:

(a) Recurrence relations for solution  $m(n, s)$  among different values of  $s$  :

(i)  $[m(n, s + 2) + D]^{1/2} - [m(n, s + 1) + D]^{1/2} + [m(n, s) + D]^{1/2} = 0$   
 where  $f(s) = s^2 + 4s - 4$

(ii)  $[m(n, s + 2) + D]^{1/2} - [m(n, s + 1) + D]^{1/2} + 2[m(n, s) + D]^{1/2} - \sum_{i=0}^{n-1} [m(i, s) + D]^{1/2} = 0$   
 where  $f(s) = s^2 + 8s - 7$

(iii)  $[m(n, s + 2) + D]^{1/2} - 2[m(n, s + 1) + D]^{1/2} + [m(n, s) + D]^{1/2} = 0$   
 where  $f(s) = s^2 + 2s + 2, s^2 + 6s + 13$

(b) Recurrence relations for solution  $m(n, s)$  among different values of  $n$  :

(i)  $[m(n, s) + D]^{1/2} - 4[m(n + 1, s) + D]^{1/2} + [m(n + 2, s) + D]^{1/2} = 0$   
 where  $f(s) = s^2 + 4s - 4, s^2 + 8s - 7, s^2 + 2s + 2, s^2 + 6s + 13$

**Numerical Illustrations for Type II System of Diophantine Equations  $m - D = u^2, \frac{m}{D} + (D + S) = v^2$**

**For  $D = 2$**

To determine the nature of solutions, one has to go for particular values of  $D$  and  $S$ . It is seen that  $D = 2$ , the equation is solvable when  $S = f(s) = s^2 + 2s - 2, s^2 + 4s - 1, s^2 + 6s - 2, s^2 + 10s + 4$

Substituting  $D = 2$  and  $S = f(s) = s^2 + 2s - 2, s^2 + 4s - 1, s^2 + 6s - 2, s^2 + 10s + 4$  in (8) and employing solutions of the Pell's equation  $u^2 - 2v^2 = 1$  the sequence of values of  $m$  are found to be

$$m(n, s) = \left\{ \frac{1}{2} \left[ (3 + 2\sqrt{2})^n (u_0 + v_0\sqrt{2}) + (3 - 2\sqrt{2})^n (u_0 - v_0\sqrt{2}) \right] \right\}^2 + 2$$

$n = 0, 1, 2, \dots$

where  $u_0 + \sqrt{2}v_0 = 0 + (s + 1)\sqrt{2}, u_0 + \sqrt{2}v_0 = 2 + (s + 2)\sqrt{2}, u_0 + \sqrt{2}v_0 = 4 + (s + 3)\sqrt{2},$

$u_0 + \sqrt{2}v_0 = 6 + (s + 5)\sqrt{2},$  are the fundamental solutions of  $u^2 - 2v^2 = -(2(s^2 + 2s - 2) + 6),$

$u^2 - 2v^2 = -(2(s^2 + 4s - 1) + 6), u^2 - 2v^2 = -(2(s^2 + 6s - 2) + 6),$  and

$u^2 - 2v^2 = -(2(s^2 + 10s + 4) + 6),$  respectively.

For the sake of simplicity a few solution of are presented in the following Tables





**Hari Ganesh and Mahalakshmi**

It is interesting to note that all the solutions obtained for  $f(s) = s^2 + 2s - 2$  and  $f(s) = s^2 + 4s - 1$  are even. When  $S = 1, 6, 13$  and  $S = 4, 11, 20$  the last digits of the solutions presented in Table 5 are of the following patterns respectively:

6      6      2;      6      6      2;      8      8      2  
 6      6      8;      6      6      2;      6      8      8

It is interesting to note that all the solutions obtained for  $f(s) = s^2 + 6s - 2$  and  $f(s) = s^2 + 10s + 4$  are even. When  $S = 5, 14, 25$  and  $S = 15, 28, 43$  the last digits of the solutions presented in Table 6 are of the following patterns respectively:

8      6      8;      8      6      6;      8      8      6  
 8      6      8;      8      8      2;      8      2      8

Further the solutions satisfy the following recurrence relations:

(a) Recurrence relations for solution  $m(n, s)$  among different values of  $s$  :

(i)  $[m(n, s + 2) - D]^{1/2} - 2[m(n, s + 1) - D]^{1/2} + [m(n, s) - D]^{1/2} = 0$   
 where  $f(s) = s^2 + 2s - 2, s^2 + 4s - 1, s^2 + 6s - 2, s^2 + 10s + 4$

(b) Recurrence relations for solution  $m(n, s)$  among different values of  $n$  :

(i)  $[m(n, s) - D]^{1/2} - 6[m(n + 1, s) - D]^{1/2} + [m(n + 2, s) - D]^{1/2} = 0$   
 where  $f(s) = s^2 + 2s - 2, s^2 + 4s - 1, s^2 + 6s - 2, s^2 + 10s + 4$

**For  $D = 3$**

To determine the nature of solutions, one has to go for particular values of  $D$  and  $S$ . It is seen that  $D = 3$ , the equation is solvable when  $S = f(s) = s^2 + 4s - 3, s^2 + 4s, s^2 + 10s + 9$ .

Substituting  $D = 3$  and  $S = f(s) = s^2 + 4s - 3, s^2 + 4s, s^2 + 10s + 9$  in (8) and employing solutions of the Pell's equation  $u^2 - 3v^2 = 1$  the sequence of values of  $m$  are found to be

$$m(n, s) = \left\{ \frac{1}{2} \left[ (2 + \sqrt{3})^n (u_0 + v_0 \sqrt{3}) + (2 - \sqrt{3})^n (u_0 - v_0 \sqrt{3}) \right] \right\}^2 + 3$$

$n = 0, 1, 2, \dots$

where  $u_0 + \sqrt{3}v_0 = 3 + \sqrt{3}(s + 2), u_0 + \sqrt{3}v_0 = 0 + \sqrt{3}(s + 2), u_0 + \sqrt{3}v_0 = 6 + \sqrt{3}(s + 5)$ , are the fundamental solutions of  $u^2 - 3v^2 = -(3(s^2 + 4s - 3) + 12), u^2 - 3v^2 = -(3(s^2 + 4s) + 12)$ , and  $u^2 - 3v^2 = -(3(s^2 + 10s + 9) + 12)$ , respectively.

For the sake of simplicity a few solution of are presented in the following Tables

It is interesting to note that all the solutions obtained for  $f(s) = s^2 + 4s - 3$  are even for odd values of  $S$ , even for even values of  $n$  and  $s$ . The solutions obtained for  $f(s) = s^2 + 4s$  are even for even and odd values of  $n$  and  $s$  respectively and odd for even values of  $s$ . The solutions for  $f(s) = s^2 + 10s + 9$  are odd for odd values of  $s$  and odd and even for even values of  $s$  and odd and even values of  $n$  respectively. When  $S = 2, 9, 18, S = 5, 12, 21$  and  $S = 20, 33, 48$  the last digits of the solutions presented in Table 7 are of the following patterns respectively:

2      8      2;      2      7      4      7      2      9;      2      4      4  
 4      9      8      9      4      3;      7      7      3;  
 8      3      8      3      8      3





**Hari Ganesh and Mahalakshmi**

9 3 9; 9 2 9 4 7 4; 9 9 7

Further the solutions satisfy the following recurrence relations:

(a) Recurrence relations for solution  $m(n, s)$  among different values of  $s$  :

(i)  $[m(n, s + 2) - D]^{1/2} - 2[m(n, s + 1) - D]^{1/2} + [m(n, s) - D]^{1/2} = 0$   
 where  $f(s) = s^2 + 4s - 3, s^2 + 4s, s^2 + 10s + 9$

(b) Recurrence relations for solution  $m(n, s)$  among different values of  $n$  :

(i)  $[m(n, s) - D]^{1/2} - 4[m(n + 1, s) - D]^{1/2} + [m(n + 2, s) - D]^{1/2} = 0$   
 where  $f(s) = s^2 + 4s - 3, s^2 + 4s, s^2 + 10s + 9$

**Numerical Illustrations for Type II System of Diophantine Equations  $m - D = u^2, \frac{m}{D} + (D - S) = v^2$**

**For  $D = 2$**

To determine the nature of solutions, one has to go for particular values of  $D$  and  $S$ . It is seen that  $D = 2$ , the equation is solvable when  $S = f(s) = s^2 - 2s + 2, s^2 + 4s - 1, s^2 + 4s + 7, s^2 + 10s + 10$ .

Substituting  $D = 2$  and  $S = f(s) = s^2 - 2s + 2, s^2 + 4s - 1, s^2 + 4s + 7, s^2 + 10s + 10$  in (9) and employing solutions of the Pell's equation  $u^2 - 2v^2 = 1$  the sequence of values of  $m$  are found to be

$$m(n, s) = \left\{ \frac{1}{2} \left[ (3 + 2\sqrt{2})^n (u_0 + v_0\sqrt{2}) + (3 - 2\sqrt{2})^n (u_0 - v_0\sqrt{2}) \right] \right\}^2 + 2$$

$n = 0, 1, 2, \dots$

where  $u_0 + \sqrt{2}v_0 = 2s + (s + 1)\sqrt{2}, u_0 + \sqrt{2}v_0 = (2s + 8) + (s + 6)\sqrt{2},$

$u_0 + \sqrt{2}v_0 = (2s + 4) + (s + 2)\sqrt{2}, u_0 + \sqrt{2}v_0 = (2s + 16) + (s + 11)\sqrt{2},$  are the fundamental solutions of  $u^2 - 2v^2 = 2(2s^2 - 2s + 2) - 6, u^2 - 2v^2 = 2(s^2 + 4s - 1) - 6, u^2 - 2v^2 = 2(s^2 + 4s + 7) - 6,$  and  $u^2 - 2v^2 = 2(s^2 + 10s + 10) - 6,$  respectively.

For the sake of simplicity a few solution of are presented in the following Tables

It is interesting to note that all the solutions obtained for  $f(s) = s^2 - 2s + 2$  are even. When  $S = 1, 2, 5, 10, 17, 26$  the last digits of the solutions presented in Table 8 are of the following patterns respectively:

6 8 6; 8 8 2; 6 8 8;  
 8 8 6; 8 8 2; 6 8 6

It is interesting to note that all the solutions obtained for  $f(s) = s^2 - 2s + 2$  are even. When  $S = 4, 11, 20, S = 12, 19, 28$  and  $S = 21, 34, 49$  the last digits of the solutions presented in Table 9 are of the following patterns respectively:

6 2 6; 8 6 6; 8 6 8  
 8 2 8; 6 2 6; 2 2 2  
 8 6 6; 6 6 2; 2 6 6

Further the solutions satisfy the following recurrence relations:

(a) Recurrence relations for solution  $m(n, s)$  among different values of  $s$  :





### Hari Ganesh and Mahalakshmi

$$(i) [m(n, s + 2) - D]^{1/2} - [m(n, s + 1) - D]^{1/2} + [m(n, s) - D]^{1/2} + [m(n - 1, s + 1) - D]^{1/2} = 0, \text{ for } s = 1$$

$$[m(n, s + 2) - D]^{1/2} - 2[m(n, s + 1) - D]^{1/2} + [m(n, s) - D]^{1/2} = 0, \text{ for } 3 \leq s \leq 9$$

$$\text{where } f(s) = s^2 - 2s + 2$$

$$(ii) [m(n, s + 2) - D]^{1/2} - 2[m(n, s + 1) - D]^{1/2} + [m(n, s) - D]^{1/2} = 0 \text{ for } n = 0$$

$$[m(n, s + 2) - D]^{1/2} - 2[m(n, s + 1) - D]^{1/2} + [m(n - 1, s) - D]^{1/2} = 0 \text{ for } n \geq 1$$

$$\text{where } f(s) = s^2 + 4s - 1$$

$$(iii) [m(n, s + 2) - D]^{1/2} - 2[m(n, s + 1) - D]^{1/2} + [m(n, s) - D]^{1/2} = 0$$

$$\text{where } f(s) = s^2 + 4s + 7, s^2 + 10s + 10$$

(b) Recurrence relations for solution  $m(n, s)$  among different values of  $n$  :

$$(i) [m(n, s) - D]^{1/2} - 6[m(n + 1, s) - D]^{1/2} + [m(n + 2, s) - D]^{1/2} = 0$$

$$\text{where } f(s) = s^2 - 2s + 2, s^2 + 4s - 1, s^2 + 4s + 7, s^2 + 10s + 10$$

## CONCLUSION

In this work, we obtained infinitely many integer solutions of the proposed system of double equations  $m \pm D = u^2$  and  $\frac{m}{D} \mp (D \pm S) = v^2$  in order to analyze the specific algebraic form of square numbers. In order to arrive the square number with specific algebraic form, the proposed system of double equations have been converted spontaneously to the familiar Diophantine equation of Pellian form. As a result, we could arrive infinitely many square numbers with specific algebraic form from the non-negative integrals solutions of the proposed system. Finally, we have also arrived some recurrence relations satisfied by the solutions of the system of double equations.

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**Hari Ganesh and Mahalakshmi**

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**Table 1:**  $m(n, s)$  for  $f(s) = s^2 + 4s - 1, s^2 + 6s - 2$

n	$m(n, s)$ for $f(s) = s^2 + 4s - 1$			$m(n, s)$ for $f(s) = s^2 + 6s - 2$		
	$(D, s, S)$			$(D, s, S)$		
	$(2, 1, 4)$	$(2, 2, 11)$	$(2, 3, 20)$	$(2, 1, 5)$	$(2, 2, 14)$	$(2, 3, 25)$
0	14	34	62	14	34	62
1	254	674	1294	142	482	1022
2	8462	22498	43262	4622	15874	33854
3	287294	763874	1468942	156814	538754	1149182
4	9759374	25948834	49900094	5326862	18301282	39037502
5	331531262	881496098	1695133582	180956302	621704354	1326125054

**Table 2:**  $m(n, s)$  for  $f(s) = 4s^2 + 4s - 2, 2s^2 + 8s + 5$

n	$m(n, s)$ for $f(s) = 4s^2 + 4s - 2$			$m(n, s)$ for $f(s) = 2s^2 + 8s + 5$		
	$(D, s, S)$			$(D, s, S)$		
	$(2, 1, 6)$	$(2, 2, 22)$	$(2, 3, 46)$	$(2, 1, 15)$	$(2, 2, 29)$	$(2, 3, 47)$
0	34	98	98	34	62	98
1	898	2498	1154	322	574	898
2	30274	84098	37634	10402	18494	28898
3	1028194	2856098	1276898	352834	627262	980098
4	34928098	97022498	43375394	11985442	21307454	33292898
5	1186526914	3295908098	1473484994	407151682	723825214	1130976898

**Table 3:**  $m(n, s)$  for  $f(s) = s^2 + 4s - 4, s^2 + 8s - 7$

n	$m(n, s)$ for $f(s) = s^2 + 4s - 4$			$m(n, s)$ for $f(s) = s^2 + 8s - 7$		
	$(D, s, S)$			$(D, s, S)$		
	$(3, 1, 1)$	$(3, 2, 8)$	$(3, 3, 17)$	$(3, 1, 2)$	$(3, 2, 13)$	$(3, 3, 26)$
0	6	33	6	6	78	6
1	33	573	321	78	1293	438
2	438	8097	4758	1086	18222	6558
3	6081	112893	66561	15126	254013	91806
4	84678	1572513	927366	210678	3538158	1279158
5	1179393	21902397	12916833	2934366	49280397	17816838







**Hari Ganesh and Mahalakshmi**

**Table 4:**  $m(n, s)$  for  $f(s) = s^2 + 2s + 2, s^2 + 6s + 13$

$n$	$m(n, s)$ for $f(s) = s^2 + 2s + 2$			$m(n, s)$ for $f(s) = s^2 + 6s + 13$		
	$(D, s, S)$			$(D, s, S)$		
	$(3, 1, 5)$	$(3, 2, 10)$	$(3, 3, 17)$	$(3, 1, 20)$	$(3, 2, 29)$	$(3, 3, 40)$
0	6	6	6	141	222	321
1	141	222	321	2301	3597	5181
2	2022	3246	4758	32397	50622	72897
3	28221	45366	66561	451581	705597	1016061
4	393126	632022	927366	6290061	9828222	14152641
5	5475597	8803086	12916833	87609597	136889997	197121597

**Table 5:**  $m(n, s)$  for  $f(s) = s^2 + 2s - 2, f(s) = s^2 + 4s - 1$

$n$	$m(n, s)$ for $f(s) = s^2 + 2s - 2$			$m(n, s)$ for $f(s) = s^2 + 4s - 1$		
	$(D, s, S)$			$(D, s, S)$		
	$(2, 1, 1)$	$(2, 2, 6)$	$(2, 3, 13)$	$(2, 1, 4)$	$(2, 2, 11)$	$(2, 3, 20)$
0	66	146	258	6	6	6
1	2306	5186	9218	326	486	678
2	78402	176402	313602	11238	16902	23718
3	2663426	5992706	10653698	381926	574566	806406
4	90478146	203575826	361912578	12974406	19518726	27394758
5	3073593602	6915585602	12294374402	440748038	663062502	930616038

**Table 6:**  $m(n, s)$  for  $f(s) = s^2 + 6s - 2, s^2 + 10s + 4$

$n$	$m(n, s)$ for $f(s) = s^2 + 6s - 2$			$m(n, s)$ for $f(s) = s^2 + 10s + 4$		
	$(D, s, S)$			$(D, s, S)$		
	$(2, 1, 5)$	$(2, 2, 14)$	$(2, 3, 25)$	$(2, 1, 15)$	$(2, 2, 28)$	$(2, 3, 43)$
0	18	18	18	38	38	38
1	786	1026	1298	1766	2118	2502
2	26898	35346	44946	60518	72902	86438
3	913938	1201218	1527698	2056358	2477478	2937798
4	31047186	40806546	51897618	69856166	84162278	99800102
5	1054690578	1386221826	1762992146	2373053798	2859040902	3390267078

**Table 7:**  $m(n, s)$  for  $f(s) = s^2 + 4s - 3, s^2 + 4s, s^2 + 10s + 9$

$n$	$m(n, s)$ for $f(s) = s^2 + 4s - 3$			$m(n, s)$ for $f(s) = s^2 + 4s$		
	$(D, s, S)$			$(D, s, S)$		
	$(3, 1, 2)$	$(3, 2, 9)$	$(3, 3, 18)$	$(3, 1, 5)$	$(3, 2, 12)$	$(3, 3, 21)$
0	12	12	12	84	147	228
1	228	327	444	1299	2307	3603
2	3252	4764	6564	18228	32403	50628
3	45372	66567	91812	254019	451587	705603





**Hari Ganesh and Mahalakshmi**

4	632028	927372	1279164	3538164	6290067	9828228
5	8803092	12916839	17816844	49280403	87609603	136890003
<i>n</i>	$m(n, s)$ for $f(s) = s^2 + 10s + 9$					
	$(D, s, S) = (3, 1, 20)$		$(D, s, S) = (3, 2, 33)$		$(D, s, S) = (3, 3, 48)$	
0	39		39		39	
1	903		1092		1299	
2	12999		15879		19047	
3	181479		221844		266259	
4	2528103		3090567		3709479	
5	35212359		43046724		51667347	

**Table 8:**  $m(n, s)$  for  $f(s) = s^2 - 2s + 2$

<i>n</i>	$m(n, s)$ for $f(s) = s^2 - 2s + 2$					
	$(D, s, S)$					
	$(2, 1, 1)$	$(2, 2, 2)$	$(2, 3, 5)$	$(2, 4, 10)$	$(2, 5, 17)$	$(2, 6, 26)$
0	6	18	6	18	38	66
1	198	578	38	258	678	1298
2	6726	19602	1158	8466	22502	43266
3	228486	665858	39206	287298	763878	1468946
4	7761798	22619538	1331718	9759378	25948838	49900098
5	263672646	768398402	45239078	331531266	881496102	1695133586
<i>n</i>	$m(n, s)$ for $f(s) = s^2 - 2s + 2$					
	$(D, s, S)$					
	$(2, 7, 37)$	$(2, 8, 50)$	$(2, 9, 65)$	$(2, 10, 82)$	$(2, 11, 101)$	$(2, 12, 122)$
0	102	146	198	258	198	258
1	2118	3138	4358	5778	1766	3602
2	70758	104978	145926	193602	56646	118338
3	2402502	3564546	4955078	6574098	1920998	4016018
4	81613158	121088018	168324678	223323138	65254086	136422402
5	2772443718	4113426498	5718081926	7586410002	2216714726	4634341778

**Table 9:**  $m(n, s)$  for  $f(s) = s^2 + 4s - 1, s^2 + 4s + 7, s^2 + 10s + 10$

<i>n</i>	$m(n, s)$ for $f(s) = s^2 + 4s - 1$			$m(n, s)$ for $f(s) = s^2 + 4s + 7$		
	$(D, s, S)$			$(D, s, S)$		
	$(2, 1, 4)$	$(2, 2, 11)$	$(2, 3, 20)$	$(2, 1, 12)$	$(2, 2, 19)$	$(2, 3, 28)$
0	6	18	38	38	66	102
1	102	146	486	902	1602	2502
2	3366	4626	15878	30278	53826	84102
3	114246	156818	538758	1028198	1827906	2856102
4	3880902	5326866	18301286	34928102	62094402	97022502
5	131836326	180956306	621704358	1186526918	2109381186	3295908102
<i>n</i>	$m(n, s)$ for $f(s) = s^2 + 10s + 10$					





**Hari Ganesh and Mahalakshmi**

	$(D, s, S)$		
	$(2, 1, 21)$	$(2, 2, 34)$	$(2, 3, 49)$
0	38	66	102
1	326	786	1446
2	10406	25602	47526
3	352838	868626	1612902
4	11985446	29506626	54789606
5	407151686	1002355602	1861232166





## Adventure Sports : A New Trend

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### ABSTRACT

Adventure sports have acquired powerful popularity in recent years, emerging as a new inclination in the dimension of outdoor activities. Especially, youth getting attracted towards adventure sports worldwide. This research paper aims to explore the growing interest in adventure sports, benefits, and impact on individuals and society. The economic and environmental collision can provide a valuable insight into future prospects of adventure sports as an emerging leisure activity and in addition it recommendation for ensuring safety and sustainability in this emerging trend. The role of technology cannot be denied at any cost for promoting it rapidly. An overview discusses of physical and psychological prerequisite while participating in these activities and explores the potential risks and challenges involved.

**Keywords:** Adventure Sports, Psychological, Physical Benefits& Economic Impact.

## INTRODUCTION

An adventure sport is known for physical action, skill, recreation and risk taking activities which are involved at a high degree. Adventure sports takes place in natural environmental condition such as mountains, water bodies and in the air. It basically involves overcoming different aspect such as uncertainty, danger and adrenaline apt spot were the participants challenges oneself to face by participating in it. There are various reasons why people have a negative tendency over adventure sports which are the fear to participate, lack of opportunities, motivational sources and knowledge.



**Sushama Narayan Chougule and Sandeep Sadashivrao Shinde**

1. Wide ranges of sporting activities are involved in adventure sports.
2. Rock climbing: Specially designed equipment are used for steep rock formation or artificial wall climbing
3. Skydiving: Free-falling from an altitude before opening of a parachute.
4. Water rafting: Boating in a swift flowing river.
5. Paragliding: There is no definite design for paragliding but it is lightweight, free-flying, foot-launched glider aircraft where the pilot sits or lies in a 'pod' dangling underneath a fabric wing.
6. Mountain biking: Bikes designed specially to ride on an off-road or on the rough terrain like mountain, desert or rocks.
7. Cave diving: Scuba diving along with underwater caves often in remote environment linked with cave diving.
8. Base jumping: Parachuting from heighted cliff building, tower or bridge.
9. Bungee Jumping: elastic cord connected for safety purpose while jumping from height which may be bridge or platform.
10. Surfing: Tremendous balance and agility required for riding ocean waves on a surfboard.
11. Snowboarding: Single board is required for sliding from a descending slope covered with snow.

All the above activities are performed by the participant as it provides a sense of thrill, adventure and test their physical and mental limits. These sports required proper training, high tech equipment and lot of safe precautions so that no major injuries take place. Extreme sports may be acknowledged as a fruitful approach for constraining people in health-enhancing and impelling lifestyles. Especially Young clan and aspirant should be inspired to take part in these activities to promote social interaction, low pressure learning, and socio-cultural alliance. Taking part in high-risk sports is by and large voluntary and people who are ready physically and mental are involved in the hazard sporting activities. Personal knowledge and technical skills allow participants to manage their exposure to these hazards within reason (Haegeli and Probstl Haider, 2016)[6]. People who choose adventurous sports are optimistic in nature and can at ease handle life threatening situation with awareness, focus and concentration.

Adventure sports are phenomenal venture performed by individuals who are in seeking to find something excitement, extra enthusiasm and have the caving to explore nature. These sports are built out of adventurous interest of individuals who wish to canvass the nature out of curiosity. One possible explanation for this is that the vast majority of high- risk sports are performed outside in the natural environment, this type of environment has been shown to provide greater physiological and psychological benefits than exercising indoor (Ryan et.al, 2010)<sup>8</sup>. Adventure sports unquestionably possess things which are challenging to find in other sports. For some people, adventure sports have been device in sprouting confidence. It arouses the intrinsic dynamic force and administers the potentials to ambit self-actualization. Adventure is a fearless and courage's activity with the coordination of mind, soul and body in extreme challenging actions. In the process of active involvement in adventure sports which intentionally or unintentionally creates life long memories. By involvement in adventure sports people have learned to undertake challenges, emotionally strong, creating friendship with nature and gaining more confidence in life. Survival of the fittest comes handy with adventure. Adventure sports are like a medium to disconnect from the real world.

**Historical Outlook**

Ancient time's warriors and athletes were engaged in daring feats. A nomad people were hunters, an explorer and an innovator. Adjusting to geographic calamity and adapting to surrounding mountains and valleys, rivers, seas and ocean. and overcoming the challenging. The history of adventure sports dates back to ancient times, with records of explorers, warriors and athletes engaging in daring feats. This section will provide an overview of the evolution of adventure sports and how they transformed from exclusive endeavors of a select few to widely leisure activities.

**Factors Driving Popularity**

This section will speculate on the future of adventure sports, taking into account societal trends, technological advancements, and potential challenges. It will explore how adventure sports may evolve and adapt to changing preferences and demographics in the coming year.



**Sushama Narayan Chougule and Sandeep Sadashivrao Shinde****Physical and Psychological Benefits**

Adventure sports means excitement, thrill and risk bearing activity. Other point to be noted is that understanding the motivation of individuals engaging in adventure sports is essential to comprehend the growing trend. Psychological factors such as risk-taking behavior, the desire for novelty, excitement, the search for adrenaline rushes, and the challenges of conquering fear are the main purpose of adventure sports. Above figure gives an overall health benefits who are engaged in such type of activities. Delving a positive impact while participating in adventure sports, includes stress reduction, increased self-confidence, and improved well-being. Research has shown a positive correlation between adventure sports and mental health benefits. In many sports, the benefits of participation extend far beyond the competition arena, positively influencing a number of health-related outcomes and behaviours (Pate, R.R., Trost, S.G.: Levein.: Dowda2000)[7]. Physically challenging oneself can be learned from adventure experience which straightly deals with individual capacities and adapt to everyday life. There is widespread knowledge and a body of evidence-based research on the importance of physical activity especially for physical and mental health and wellbeing (Cavill. N, 2006)[5].

**Predominant Adventure Sports**

In past adventure sports have been predominantly male-dominated. This section will explore the changing dynamics and the increasing participation of women in adventure sports. It will analyze the challenges faced by female participants and the efforts made to foster inclusivity and gender equality in the adventure sports community. Adolescence stage people are attracted towards recreational activities, including in adventure and extreme sports. Sport and recreation is the main root of injury in youth and may govern intentional to lower level of physical activity and which lead to negative impact on future health. Other research suggest that high-risk sports allow participants to: experience freedom and thus, explore fundamental human values (Brymr and Schweitzer, 2013b)[4]; experience fear and anxiety which has transformational benefits (Brymer and Schweitzer, 2013a)[3]; and develop courage and humility (Brymer and Oades, 2009)[2]. It has long been accepted that the primary motives for participation in adventure activities is the intrinsic psychological benefits to be gained by individuals from recreational challengers (Hall, 1992)[9]. Adventure sports are generally related with instinctive human inclination for risk taking and the search for excitement.

**Socioeconomic impact**

The rise of adventure sports has not only affected individual participants but also had broader economic implications. This section will analyze the economic impact of adventure sports on local communities, tourism industries and related businesses. It will explore the creation of adventure sports hubs, the growth of adventure tourism, and the employment opportunities it generates. As outdoor sports provide opportunities and places for social interaction, contacts, and relations they can lead to increased social connectedness and are therefore associated with various benefits of active citizenship. This included volunteering and community benefits such as the construction and maintenance of local community life, identify and pride (Beaumont E., Brown D.H.K. (2015)[1].

**Environmental and safety concerns**

While adventure sports offer unique experiences, they often take place in natural and fragile environments. The potential impact of adventure sports on the environment and strategies for promoting responsible and sustainable practices. Moreover, the safety concerns associated with these high-risk activities must be addressed with priority of participant well-being. Furthermore, there is growing evidence that people enjoy being with the nature or having contact with natural environment (Ten Brink, 2016)[10]. <https://www.statista.com/outlook/dmo/app/games/adventure-games/india>. The above chart gives a clear picture about the increase in adventure games from 2017 to near future what the market is expected to be. The forecast is pretty clear that we need to study the market more and upgrade it. India has more opportunities to progress in adventure field.

**Economic Impact**

Currently adventure travel has been the state of art within the tourism economy. Taking account of surge attraction and enthusiasm of people in such activities the government had to take initiatives to support and reinforcement the





**Sushama Narayan Chougule and Sandeep Sadashivrao Shinde**

growth of adventure sports. The piece of attraction will be boosted with the help of social media as well as travellers and video blogging. The area those are popular for extreme sports events capture sports tourism especially the host country. It has not only opened the door for working opportunities, but also imparts a brand new experience for visitors. <https://www.travelweekly.com/Travel-News/Tour-Operators/Report-finds-significant-growth-in-adventure-travel-market> The above study also indicated that there are fresh opportunities for the trade to grab this market and which will be an ideal move to earn attractive profit. The above chart shows the different tools used by the adventure seeking travelers to reach their destination. The program must be logical and worthy who are looking to make their future as designation managers or tour operators need to learn more about the adventure travel market. A crucial training and specialization client is essential to be executed in adventure travel safety and satisfactorily. It must be backed up with the best-of breed trainers from hard skills to soft skills. The adventure market needs to be bloomed up with the proper advertisement. The Government and media plays a major role for hiking employment opportunities and tourism which will result to increase the GTP of the country.

**CONCLUSION**

New generation people are inclined to experience something distinct memories and, to create amazing memories and increase excitement to their wish lists. Adventure sports have appeared to be in important cultural phenomenon, captivating individuals for pursuing thrill, challenge, and daring act. This research paper highlights the factors driving the rise of adventure sports, its impact on individuals and communities. As adventure sports continue to gain momentum, it is crucial to strike a balance between preserving the natural environment and maximizing the benefits of this trend for both participants and society as a whole.

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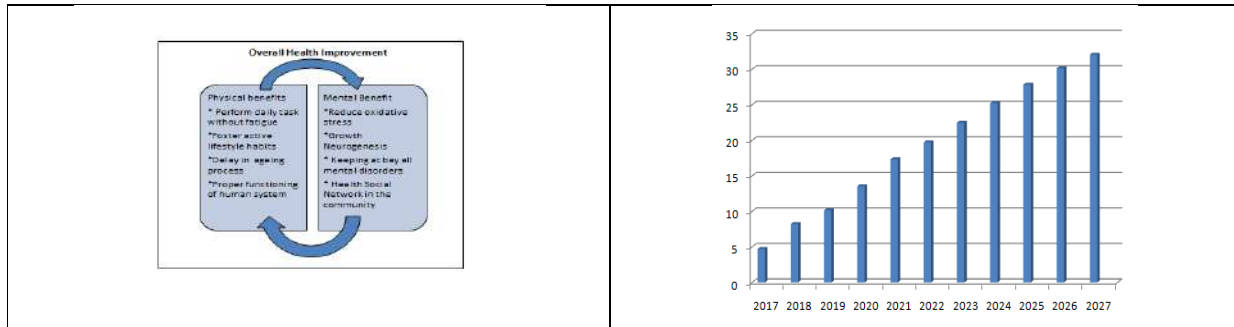
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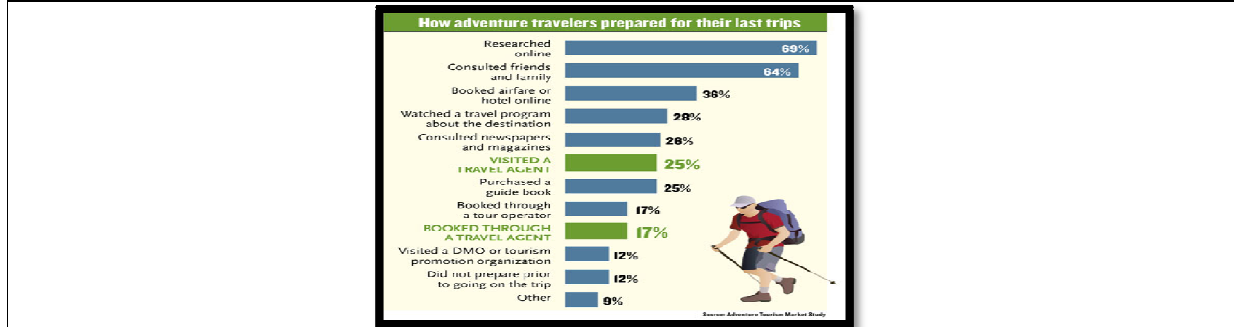
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**Fig: 1 Overall Health Improvement**

**Fig 2: Forecast of Adventure Games**



**Fig 3: Travellers Chart for Adventure Trip**





## Effect of Preparatory Process and Antimicrobial Finish on Physical Properties of the Ramie Fiber (*Boehmeria nivea*)

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### ABSTRACT

The study focused on the development of bacterial-resistant ramie fiber using jamun (*Syzygium cumini*) leaf extract. It is also intended to produce eco-friendly antimicrobial fiber and to protect consumers from infections. The antimicrobial finish has been imparted to the fiber by direct method. The physical properties of retted, preparatory, and finished samples were tested to analyze the effect of these processes on the physical properties of the fiber, and the result showed that the preparatory process and antimicrobial finish had made positive effect on ramie fiber.

**Keywords:** Ramie, Bacterial-resistant Eco-friendly, Antimicrobial.

### INTRODUCTION

Natural fibers are a type of renewable and ecologically acceptable source best known for their biodegradability, non-carcinogenic, and health-friendly nature that played a significant role in human civilization. Natural fibers are one such proficient material that replaces synthetic materials and their related products for less weight and energy conservation applications (Vastrad & Byadgi, 2018). In recent years the use of natural fiber has increased due to raising consciousness about the clean environment. The application of natural fibers is now considered more seriously because of growing environmental awareness. The consumer is giving the top most priority to natural





Suravi Konwar *et al.*,

fibers as they are eco-friendly, biodegradable, lower CO<sub>2</sub> emissions, and are cost-effective (Konwar and Boruah, 2018). Natural fibers are progressively used in a wide range of applications, for instance, in furniture, automotive, electronic industries, building construction, and medical and hygienic products (Bledzki *et al.*, 2002). Ramie (*Boehmeria nivea*) is a compatible natural cellulosic fiber that has excellent quality, luster, strength, and durability. For the unique intensity and absorbance, it is simple to combine with a variety of other fibers. The fiber is widely used in making apparel, curtains, draperies, upholsteries, filter cloths, etc., and is also used for the production of diversified items (Mitra *et al.*, 2014). Ramie fiber is highly absorbent due to the cellulose polymer unit in the fiber structure. The fiber is very rigid and crystalline but is exceptionally porous, which gives better absorbency (Jose *et al.*, 2017). In recent days, researchers have been attracted to the utilization of natural fibers in the diverse field of textiles because of their low cost, renewable, abundant, higher formability, and eco-friendly features. Natural fibers have good mechanical strength and low weight which leads to demand for applications in the engineering field. Based on the sustainability benefits, natural fibers are now rapidly replacing synthetic fibers in composites and also finding wide applications starting from automotive applications to textile manufacturers who are focusing on utilizing natural fibers as raw materials to enhance their arts and skills in their industries (Kumar & Mitra, 2013). Therefore, the present study was attempted to analyze the physical properties of treated ramie fibers to evaluate the potential of fiber for its end uses. The study was intended with the following objectives.

1. To study the physical properties of retted ramie fiber.
2. To test the physical properties of treated ramie fiber.

## MATERIALS AND METHODS

The materials and methods used in the study are as follows.

### Raw material

Ramie fibers were procured from Ramie Research Station, Shorbhog, Assam.

### Preparatory process of ramie fiber

**Degumming Process:** In the degumming process, a 1:10 bath ratio was maintained. Decorticated ramie fibers were treated with a 3% solution of Na<sub>2</sub>CO<sub>3</sub> at 100°C for 2 hours. The degummed fibers were rinsed with cold water, neutralized with 2% acetic acid, rinsed again until neutral pH, and dried at 50°C in a vacuum oven (Kalita, 2005).

**Bleaching Process:** Bleaching was done by using alkaline hydrogen peroxide with a material-to-liquor ratio of 1:10 at 100°C, pH 10-11 for 60 minutes in a closed vessel. After bleaching, the fiber was washed properly and air-dried (Kalita, 2005).

### Preparation of plant extract for application on ramie fiber

Collected fresh leaves (*Syzygiumcumini*) were first washed in tap water 2-3 times to clean the soil then washed in distilled water. Leaves were cut into small sizes, dried in the shade, and grounded. Then the mixtures were dipped in methanol solution in a 250 ml conical flask at room temperature (27-30°C). After 48 hours, the suspension was filtered through muslin cloth and finally through a What man filter paper (No. 4) to separate the plant extracts supernatant and then centrifuged at 10,000 rpm for 15 min. The prepared extracts solution was sterilized at 100°C for 15 min and kept for 4 days. After that extract were used for testing different parameters.

### Application of antimicrobial finishes on fibers

A direct application method was used for this study where the samples were immersed into the extract, and 5% citric acid was used as a cross-linking agent for this assay. The samples were then incubated in sealed conditions for 24 hours.



Suravi Konwar *et al.*,**Evaluation of physical properties after preparatory processes and antimicrobial finishing**

Physical properties of raw, degummed, bleached and antimicrobial finished samples were tested to analyze the effect of these processes on the physical properties of the fiber. The physical properties of the fibers were analyzed as per the standard test methods.

**RESULTS AND DISCUSSION****Effect of preparatory processes and antibacterial finish on physical properties of raw fiber**

Retted ramie fibers were selected for the study. Retted ramie was subjected to degumming and bleaching. Degumming involves the removal of starch and impurities present in the fabric to make it more absorbent for further textile processing and Bleaching improves the whiteness property and also imparts uniform absorbency and a high degree of finish ability. The pretreated ramie fibers were studied concerning changes in physical properties. Then the antimicrobial finished ramie fibers were studied to analyze the effect of jamun (*Syzygiumcumini*) leaf extract on the physical properties of fibers. The parameters i.e. length, diameter, wall thickness, fiber fineness, wicking height, moisture regain, tensile strength, elongation, and density of selected fiber were evaluated (Tables 1, 2, 3, 4, and 5). A decreasing trend was noticed in the case of fiber length, diameter, and wall thickness respectively. The experimental data presented in Table 1 showed that the length of the fiber was found to be highest in retted fiber (121.33 mm) followed by degummed (118 mm), bleached (117.33 mm), and finished (116.66 mm) ramie fiber respectively.

The fiber length is an important property that influences the quality of the end product. A similar work related to fiber length was reported by (Kalita *et al.*, 2019). It was also noticed that the diameter of the ramie fiber decreased as it was subjected to different processes. The maximum diameter (12.46 $\mu$ m), was recorded in retted fiber, and the minimum diameter (7.9 $\mu$ m), was recorded in finished. Fiber diameter plays a vital role in determining the quality of the textile. A decrease in diameter in treated fiber implied that fiber became softer in comparison with untreated fiber as most of the gummy substances were removed during degumming, bleaching, and finishing treatment. The difference in length and diameter of raw, preparatory, and finished fiber might be due to the wet processing of fiber (Gohl and Vilensky, 1997). The empirical variance ratio in the ANOVA test and corresponding CD value of length and diameter for all the samples were significant at a 5% level of significance. With regards to the wall thickness of fiber, it was observed from Table (2) that after degumming (2.53 $\mu$ m), bleaching (2.41 $\mu$ m), and finishing (2.26 $\mu$ m), the wall thickness gradually decreased. After different wet processing treatments, there was an improvement in fiber fineness due to the removal of lignin and gummy substances from the fiber. It was also noticed from Table (1) that after degumming, bleaching, and finishing treatment, there was an improvement in fiber fineness due to the removal of lignin and gummy substances from the fiber. This result has been shown in conformity with the work of (Tamta, 2018). However, the ANOVA of the statistical data of wall thickness and fiber fineness showed that there are statistical differences between all samples. The statistical data reveal that the p-value is less than 0.05 so there is a significant difference between the samples at a 5% level of significance.

The wicking height and moisture regain of preparatory processes and antimicrobial finish fibers were assessed and data were systematically presented in Table (3). In regards to the wicking height and moisture regain, the maximum wicking height (19.27%), and moisture regain (9.43%) were recorded in finished fiber and the minimum wicking height (13.28%), and moisture regain (8.51%) were recorded in retted fiber. This might be due to the swelling of fiber during the preparatory and finishing process. According to (Thygesen *et al.*, 2007), increasing moisture regain and wicking height might be the reason for more lumen presence that lumen structure has great affinity towards the water which is a distinct benefit of natural fibers Further, the ANOVA of the statistical results showed a significant difference between the samples. The statistical data revealed that the p-value is less than 0.05 so there was a significant difference between the samples at a 5% level of significance. The experimental data obtained from the Density are listed in table (4). Table indicated that the density of ramie fiber was found to be maximum (1.48 g/cm<sup>3</sup>) in case of finished followed by bleached (1.38 g/cm<sup>3</sup>), degummed (1.29 g/cm<sup>3</sup>), and retted (1.09 g/cm<sup>3</sup>) ramie fiber.





Suravi Konwar *et al.*,

The increase in density might be due to the removal of hemi cellulose and lignin during the preparatory processes and antimicrobial treatment. The ANOVA relating to density depicted a significant difference between all the samples. From the analysis, it was also revealed that the density of all the samples showed a highly significant difference at a 5% level of significance. Table (5) revealed that the tensile strength of ramie fiber was decreased as it was subjected to a different process. It was also noticed that among the treated ramie fibers, the maximum tensile strength (40.30 g/tex) was observed in retted fiber, and the least was recorded in finished fiber (27.20 g/tex). The tensile strength of fiber was decreased from 40.30 g/tex to 27.20 g/tex and it might be due to the loss of hemi cellulose content and lignin during prolonged preparatory processes and antimicrobial treatment (Boehlert *et al.*, 1997). The elongation relationship of all the processed and finished ramie fiber was also presented in Table 5. The finished ramie showed the highest elongation (2.20%) followed by bleached (2.10%), degummed (1.76%), and retted (1.60%) ramie fiber. When the elongation increases, the strength of the fiber decreases (Hazarika, 2021). According to Saxena *et al.*, (2011), ramie fiber has strength properties per unit weight among all the natural fibers. The cell walls of ramie fiber are a composite structure, being composed of principally cellulosic micro fibrils, implanted in matrix polysaccharides and lignin. The micro fibrils are arranged with different winding angles that helically wound around the cell wall in layers. The composite structure gives ramie fiber of excellent toughness. The empirical variance ratio in the ANOVA test and corresponding CD value of tensile strength and elongation of all the samples were significant at a 5% level of significance.

## CONCLUSION

The study revealed that the maximum length (121.33mm), diameter (12.46 $\mu$ m), and wall thickness (2.86  $\mu$ m) of fiber was recorded in retted fiber. After the application of treatment on fiber, the maximum wicking height (19.27%), and moisture regain (9.43%) were recorded in finished fiber, and the minimum wicking height (13.28%) and moisture regain (8.51%) were recorded in retted fiber. The tensile strength of fibers decreases from 40.30 g/tex to 27.20 g/tex. The finished ramie showed the highest elongation (2.20%) followed by bleached (2.10%), degummed (1.76%), and retted (1.60%) ramie fiber. The density of ramie fiber was found to be maximum (1.48 g/cm<sup>3</sup>) in case of finished followed by bleached (1.38 g/cm<sup>3</sup>), degummed (1.29 g/cm<sup>3</sup>), and retted (1.09 g/cm<sup>3</sup>) ramie fiber.

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**Table 1 Effect of finishing on length (mm) and diameter ( $\mu\text{m}$ ) of finished ramie fiber**

Samples	Length (mm)	Diameter ( $\mu\text{m}$ )
Retted	121.33	12.46
Degummed	118	10.76
Bleached	117.33	8.18
Finished	116.66	7.9
SEd( $\pm$ )	0.5	0.16
CD	1.15	0.39

**Table 2 Effect of finishing on wall thickness ( $\mu\text{m}$ ) and fiber fineness (g/tex) of finished ramie fiber**

Samples	Wall thickness ( $\mu\text{m}$ )	Fiber fineness (g/tex)
Retted	2.86	3.62
Degummed	2.53	2.84
Bleached	2.41	2.44
Finished	2.26	2.14
SEd( $\pm$ )	0.01	0.21
CD	0.02	0.48

**Table 3 Effect of finishing on the wicking height and moisture regain of finished ramie fiber**

Samples	Wicking height (cm)	Moisture regain (%)
Retted	13.28	8.51
Degummed	14.55	8.87
Bleached	17.13	9.15
Finished	19.27	9.43
SEd( $\pm$ )	0.01	0.02
CD	0.03	0.05





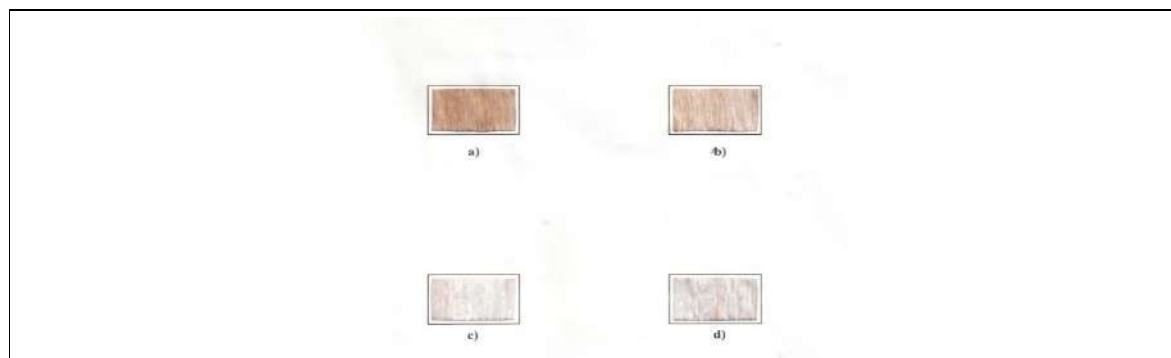
Suravi Konwar et al.,

**Table 4 Effect of finishing on Density (g/cc) of finished ramie fiber**

Samples	Density (g/cc)
Retted	1.09
Degummed	1.29
Bleached	1.38
Finished	1.48
SEd(±)	0.01
CD	0.02

**Table 5 Effect of finishing on Tensile strength (g/tex) and elongation (%) of finished ramie fiber**

Samples	Tensile strength (g/tex)	Elongation (%)
Retted	40.30	1.60
Degummed	36.43	1.76
Bleached	30.53	2.10
Finished	27.20	2.20
SEd(±)	0.24	0.02
CD	0.56	0.04



**Fig. 1-Effects of treatments on retted ramie fiber**

- a. Ramie raw fiber
- b. Ramie degummed fiber
- c. Ramie bleached fiber
- d. Ramie finished fiber





## Some Sort of Generalization in Ideal Nano Topological Spaces

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### ABSTRACT

This article presents the concept of nano generalized  $\delta I$ -closed namely  $Ng$ - $\delta I$ -closed sets in ideal nano topological space and explore its basic properties and characterizations. We establish the correlation with the known closed sets with suitable examples. Also we establish that  $Ng$ - $\delta I$ -closed sets occurs between  $N$ - $\delta$ -closed sets and  $Ng$ -closed sets. But independent of nano closed sets. Apart from that we investigate the concept of maximal  $Ng$ - $\delta I$ -closed set.

**Keywords:** nano topological space, nano ideal topological space,  $ng$ - $\delta I$ -closed sets,  $ng$ - $\delta I$ -open sets.

### INTRODUCTION

Kuratowski introduced ideals [4] in topology. A non-empty collection  $\mathcal{I} \subseteq P(U)$  is called ideal [4] if it satisfies: (i)  $S \in \mathcal{I}$  and  $T \subseteq S \Rightarrow T \in \mathcal{I}$ , and (ii)  $S \in \mathcal{I}$  and  $T \in \mathcal{I} \Rightarrow S \cup T \in \mathcal{I}$ . In [3], D. Jankovic and T.R. Hamlet introduced and studied the local function  $(\cdot)^*$  and the kuratowski closure operator  $cl^*(\cdot)$  in ideal topological spaces. In [5], Lellis Thivagar and Richard introduced nano topological space by defining the lower (resp., upper) approximation and border of a subset of the universe  $U$  using the equivalence relation  $\mathcal{R}$  and studied its various properties [6]. Nano forms of interior and closure were also defined and studied. In [15], Carmel discussed some weak nano open sets. In [8, 9, 10], M.Parimala et al. introduced nano ideal topological spaces or ideal nano topological spaces,  $N$ -local function which is defined as  $S_N^*(\mathcal{I}, \mathbb{N}) =$





**Palani and Karthigai jothi**

$\{x \in U: W \cap S \notin \mathcal{I}, \text{ for every } W \in W_N(x)\}$  where  $W_N(x) = \{W / x \in W \text{ and } W \in \mathbb{N}\}$  and the closure operator  $Ncl^*(.)$  defined as  $Ncl^*(S) = S \cup S_N^*$ , for  $S \subseteq U$  and investigated its basic properties. We use the name ideal nano topological spaces or shortly INTS and nano topological space or shortly NTS for convenience. M.Parimala et al. [11] presented the concept of  $N-\delta$ -open sets. A set  $S$  is known as  $N-\delta$ -open set if  $Ncl_\delta(S) = S$ , where  $Ncl_\delta(S) = \cup\{x \in U: Nint(Ncl(W)) \cap S \neq \emptyset, W \text{ is } n\text{-open and } x \in W\}$ . In [7] Lellis Thivagar et al., established nano kernel of a subset in INTS. For  $S \subseteq U$ ,  $Nker(S) = \cap\{W / S \subseteq W, W \text{ is } n\text{-open}\}$ . In [2] Ilangovan Rajasekaran et al., introduced nano  $\Lambda$ -sets in ideal nano topological space. If  $Nker(S) = S$  then  $S$  is  $N-\Lambda$ -set [2]. Bhuwaneswari et al. [1] established and studied  $g$ -closed sets in NTS. Yuksel S, Acikgoz A, Noiri T, [16] introduced the concept of  $\delta$ -I-open sets in ideal topological spaces. K.Palani M.Karthigai jothi [13] investigated  $N-\delta$ I-closed sets in INTS. This present work concentrates the generalized  $N-\delta$ I-closed sets in INTS.

**Preliminaries**

**Definition 2.1.** In an NTS, a subset  $S$  is known as a

- (i) Ng-closed [1] set if  $Ncl(S) \subseteq W$  when  $S \subseteq W, W \in \mathbb{N}(U)$ . Where  $\mathbb{N}(U) = \{W \subseteq U / W \text{ is } N\text{-open}\}$ .
- (ii) Ng- $\delta$ -closed [14] set if  $Ncl_\delta(S) \subseteq W$  when  $S \subseteq W, W \in \mathbb{N}(U)$ .

**Definition 2.2.** [12] In an INTS a subset  $S$  is known as an N-Ig-closed set if  $S_N^* \subseteq W$  when  $S \subseteq W, W \in \mathbb{N}(U)$ .

**Definition 2.3.** [13] Let  $(U, \mathbb{N}, \mathcal{I})$  be an INTS. For  $S \subseteq U$ ,  $Ncl_\delta I(S) = \{x \in U / Nint(Ncl^*(G)) \cap S \neq \emptyset, \text{ for each } W \in W_N(x)\}$  where  $W_N(x) = \{W / x \in W \text{ and } W \in \mathbb{N}\}$ . If  $Ncl_\delta I(S) = S$  then  $S$  is said to be an  $N-\delta$ I-closed and  $U-S$  is  $N-\delta$ I-open.  $T_\delta I = \{W / W \subseteq U, W \text{ is } N-\delta\text{I-open}\}$ .

**Lemma 2.4.** [13] For the subsets  $S$  and  $T$  of an INTS  $(U, \mathbb{N}, \mathcal{I})$ ,

- (i)  $S \subseteq Ncl_\delta I(S)$ .
- (ii) If  $S \subseteq T$ , then  $Ncl_\delta I(S) \subseteq Ncl_\delta I(T)$ .
- (iii)  $Ncl_\delta I(S) = \cap\{H \subseteq U / S \subseteq H \text{ and } H \text{ is } N-\delta\text{I-closed}\}$ .
- (iv) If  $S_j$  is  $N-\delta$ I-closed set of  $U$  for each  $j \in J$ , then  $\cap\{S_j / j \in J\}$  is  $N-\delta$ I-closed.
- (v)  $Ncl_\delta I(S)$  is  $N-\delta$ I-closed.

**Ng- $\delta$ I-Closed Sets**

This part gives the relationship of Ng- $\delta$ I-closed with some existing nano closed sets with some examples followed by the Definition.

**Definition 3.1.** In an INTS  $(U, \mathbb{N}, \mathcal{I})$ , a subset  $S$  is known as a nano generalized  $N-\delta$ I-closed (briefly, Ng- $\delta$ I-closed) if  $Ncl_\delta I(S) \subseteq W$  whenever  $S \subseteq W$  and  $W \in \mathbb{N}(U)$ . Where  $\mathbb{N}(U) = \{W / W \subseteq U, W \text{ is } N\text{-open}\}$ . Then  $U-S$  is known as Ng- $\delta$ I-open set in  $(U, \mathbb{N}, \mathcal{I})$ . The collection of Ng- $\delta$ I-closed and Ng- $\delta$ I-open sets are denoted by  $Ng-\delta IC(U, \mathbb{N}, \mathcal{I})$  (or simply,  $Ng-\delta IC(U)$ ) and  $Ng-\delta IO(U, \mathbb{N}, \mathcal{I})$  (or simply,  $Ng-\delta IO(U)$ ) respectively.

**Theorem 3.2.** In an INTS  $(U, \mathbb{N}, \mathcal{I})$ ,  $N-\delta$ -closed sets,  $N-\delta$ I-closed sets are Ng- $\delta$ I-closed.

**Proof.** Let  $S \subseteq W$  and  $W \in \mathbb{N}(U)$  in  $(U, \mathbb{N}, \mathcal{I})$ . Since  $Ncl_\delta I(S) \subseteq Ncl_\delta(S)$ ,  $Ncl_\delta I(S) \subseteq W$  by assumption. Thus  $S$  is Ng- $\delta$ I-closed. By definition the proof is true for  $N-\delta$ I-closed.

The given below Examples confirms that the reverse direction of Theorem 3.2 need not hold always.

- (a) Let  $U = \{w_1, w_2, w_3, w_4\}, X = \{w_3\} \subset U, \mathcal{U}/\mathcal{R} = \{\{w_1\}, \{w_2\}, \{w_3, w_4\}\}, \mathbb{N} = \{U, \emptyset, \{w_3, w_4\}\}$  and  $\mathcal{I} = \{\emptyset, \{w_3\}, \{w_4\}, \{w_3, w_4\}\}$ . If  $S = \{w_2, w_3, w_4\}$  then  $S \in Ng-\delta IC(U)$  but not in  $N-\delta C(U)$ .





**Palani and Karthigai jothi**

(b) Let  $U = \{w_1, w_2, w_3, w_4\}$ ,  $X = \{w_3\} \subset U$ ,  $U/R = \{\{w_1\}, \{w_2\}, \{w_3, w_4\}\}$ ,  $N = \{U, \phi, \{w_3, w_4\}\}$  and  $I = \{\phi, \{w_3\}, \{w_4\}, \{w_3, w_4\}\}$ . If  $S = \{w_1, w_2, w_3\}$  then  $S \in Ng-\delta IC(U)$  but not in  $N-\delta IC(U)$ .

**Theorem 3.3.** In an INTS  $(U, N, \mathcal{J})$ , any  $S \in Ng-\delta IC(U)$  is (i) Ng-closed (ii)  $N-I_g$ -closed.

**Proof.** (i) Suppose  $S \in Ng-\delta IC(U)$  and  $W \in N(U)$  with  $S \subseteq W$ . By hypothesis,  $N_{cl_{\delta I}}(S) \subseteq W$ . Always,  $Ncl(S) \subseteq N_{cl_{\delta I}}(S)$ . Hence,  $Ncl(S) \subseteq W$  and hence  $S$  is Ng-closed.

(ii) Since Ng-closed sets are  $N-I_g$ -closed, (ii) is true by (i).

From Example 3.4 it is true that the reversible side of Theorem 3.3 (i) and (ii) are not hold always.

**Example 3.4.** (i) Let  $U = \{w_1, w_2, w_3, w_4\}$ ,  $X = \{w_1, w_3\}$ ,  $U/R = \{\{w_1\}, \{w_2\}, \{w_3, w_4\}\}$ ,  $N = \{U, \phi, \{w_1\}, \{w_1, w_3, w_4\}, \{w_3, w_4\}\}$  and  $I = \{\phi\}$ . Then,  $Ng-\delta I$ -closed =  $\{U, \phi, \{w_2\}, \{w_1, w_2\}\}$  and Ng-closed =  $\{U, \phi, \{w_2\}, \{w_1, w_2\}, \{w_2, w_3\}, \{w_2, w_4\}, \{w_1, w_2, w_3\}, \{w_1, w_2, w_4\}, \{w_2, w_3, w_4\}\}$ .

(ii) Let  $U = \{w_1, w_2, w_3, w_4\}$ ,  $X = \{w_3\} \subset U$ ,  $U/R = \{\{w_1\}, \{w_2\}, \{w_3, w_4\}\}$ ,  $N = \{U, \phi, \{w_3, w_4\}\}$  and  $I = \{\phi, \{w_3\}, \{w_4\}, \{w_3, w_4\}\}$ . Let  $S = \{w_1, w_2, w_3\}$ . Then,  $Ng-\delta I$ -closed =  $\{U, \phi, \{w_1\}, \{w_2\}, \{w_1, w_2\}, \{w_1, w_3\}, \{w_1, w_4\}, \{w_2, w_3\}, \{w_2, w_4\}, \{w_1, w_2, w_3\}, \{w_1, w_2, w_4\}, \{w_1, w_3, w_4\}, \{w_2, w_3, w_4\}\}$  and  $N-I_g$ -closed =  $P(U)$ .

From Example 3.4 (i) and (ii), it is true that  $Ng-\delta I$ -closed sets are independent of  $N$ -closed sets

**Characterizations**

Theorem 4.1 given below gives the characterization of  $Ng-\delta I$ -closed sets.

**Theorem 4.1.** In an INTS  $(U, N, \mathcal{J})$ , the statements given below are equivalent for any  $S \subseteq U$ :

- (i)  $S$  is  $Ng-\delta I$ -closed.
- (ii)  $Ncl(\{x\}) \cap S \neq \phi$ , for any  $x \in N_{cl_{\delta I}}(S)$ .
- (iii) If  $H \subseteq N_{cl_{\delta I}}(S) - S$  and  $H$  is  $N$ -closed set then  $H = \phi$ .

**Proof.** (i)  $\Rightarrow$  (ii). If  $Ncl(\{x\}) \cap S = \phi$ , then  $S \subseteq U - Ncl(\{x\})$ . Then by assumption,  $N_{cl_{\delta I}}(S) \subseteq U - Ncl(\{x\})$  since  $Ncl(\{x\})$  is  $N$ -closed. There is a contradiction.

(ii)  $\Rightarrow$  (iii). Let  $H \subseteq N_{cl_{\delta I}}(S) - S$  and  $H$  is  $N$ -closed  $x \in H$ . Then  $H \subseteq U - S$ . Therefore,  $Ncl(\{x\}) \cap S \subseteq Ncl(H) \cap S = H \cap S = \phi$ . Since  $x \in N_{cl_{\delta I}}(S)$  by (ii),  $Ncl(\{x\}) \cap S \neq \phi$ . A contradiction and hence (iii).

(iii)  $\Rightarrow$  (i). Let  $S \subseteq W$  and  $W \in N(U)$ . Always,  $N_{cl_{\delta I}}(S)$  is  $N$ -closed. Therefore,  $N_{cl_{\delta I}}(S) \cap (X - W)$  is  $N$ -closed. Also,  $N_{cl_{\delta I}}(S) \cap (X - W) \subseteq N_{cl_{\delta I}}(S) - S$ . By hypothesis,  $N_{cl_{\delta I}}(S) \cap (X - W) = \phi$  and hence  $N_{cl_{\delta I}}(S) \subseteq W$ .

When  $I = \{\phi\}$ ,  $N_{cl_{\delta I}}(S) = N_{cl_{\delta}}(S)$  and hence  $Ng-\delta I$ -closed sets are coincides with  $N-\delta g$ -closed sets. When  $I = P(U)$ ,  $N_{cl_{\delta I}}(S) = Ncl(S)$  and hence  $Ng-\delta I$ -closed sets are coincides with  $Ng$ -closed sets. Therefore, Corollary 4.2, Corollary 4.3 holds when  $I = \{\phi\}$  and  $I = P(U)$  respectively in Theorem 4.1.

**Corollary 4.2.** In an NTS  $(U, N)$ , the statements given below are equivalent for any  $S \subseteq U$ :

- (i)  $S$  is  $N-\delta g$ -closed.
- (ii) For all  $x \in N_{cl_{\delta}}(S)$ ,  $Ncl(\{x\}) \cap S \neq \phi$ .
- (iii)  $N_{cl_{\delta}}(S) - S$  contains no nonempty  $N$ -closed set.

**Corollary 4.3.** In an NTS  $(U, N)$ , the statements given below are equivalent for any  $S \subseteq U$ :

- (i)  $S$  is  $Ng$ -closed.
- (ii)  $Ncl(\{x\}) \cap S \neq \phi$ , for any  $x \in Ncl(S)$ .
- (iii)  $Ncl(S) - S$  does not contains any nonempty  $N$ -closed set [see [1], Theorem 3.3].

**Corollary 4.4.** In an INTS  $(U, N, \mathcal{J})$ , the given below are equivalent for any  $Ng-\delta I$ -closed set  $S \subseteq U$ :

- (i)  $S$  is an  $N-\delta I$ -closed.
- (ii)  $N_{cl_{\delta I}}(S) - S$  is an  $N$ -closed.





**Palani and Karthigai jothi**

**Proof.** (i)  $\Rightarrow$  (ii). By (i),  $Ncl_{\delta I}(S) - S = \phi$  and so  $Ncl_{\delta I}(S) - S$  is N-closed.  
 (ii)  $\Rightarrow$  (i). Let  $Ncl_{\delta I}(S) - S$  is N-closed. Since  $S$  is Ng- $\delta I$ -closed, by Theorem 4.1,  $Ncl_{\delta I}(S) - S = \phi$  and hence (i) holds.  
 Corollary 4.5 and Corollary 4.6 holds when  $I = \{\phi\}$  and  $I = P(X)$  respectively in Corollary 4.4.

**Corollary 4.5.** In an NTS  $(U, \mathbb{N})$ , the statements given below are equivalent for any N- $\delta g$ -closed set  $S \subseteq U$ :

- (i)  $S$  is N- $\delta$ -closed.
- (ii)  $Ncl_{\delta}(S) - S$  is N-closed.

**Corollary 4.6.** In an NTS  $(U, \mathbb{N})$ , the statements given below are equivalent for any Ng-closed set  $S \subseteq U$ :

- (i)  $S$  is N-closed.
- (ii)  $Ncl(S) - S$  is N-closed [see [1], Theorem 3.10].

**Theorem 4.7.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$ , every  $S \subseteq U$  is Ng- $\delta I$ -closed if and only if every  $W \in \mathbb{N}(U)$  is N- $\delta I$ -closed.

**Proof.** Necessity: By assumption, any N-open set  $W$  is Ng- $\delta I$ -closed. Therefore,  $Ncl_{\delta I}(W) \subseteq W$ . Hence true.  
 Sufficiency: Let  $S \subseteq W$  and  $W \in \mathbb{N}(U)$ . Then  $Ncl_{\delta I}(S) \subseteq Ncl_{\delta I}(W) = W$  by assumption.

**Theorem 4.8.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,  $S \cup T$  is Ng- $\delta I$ -closed whenever  $S$  and  $T$  are Ng- $\delta I$ -closed.

**Proof.** Suppose that,  $S \cup T \subseteq W$  and  $W \in \mathbb{N}(U)$ . Then  $S \subseteq W$  and  $T \subseteq W$ . Since  $S$  and  $T$  are Ng- $\delta I$ -closed sets,  $Ncl_{\delta I}(S) \subseteq W$  and  $Ncl_{\delta I}(T) \subseteq W$ . Always,  $Ncl_{\delta I}(S \cup T) = Ncl_{\delta I}(S) \cup Ncl_{\delta I}(T)$ . Therefore,  $Ncl_{\delta I}(S \cup T) \subseteq W$ .  
 The given below Example shows that  $S \cap T$  is not always Ng- $\delta I$ -closed whenever  $S$  and  $T$  are Ng- $\delta I$ -closed. In Example 3.4 (ii), let  $S = \{w_1, w_3\}$  and  $T = \{w_2, w_3\}$ . Then  $S, T \in Ng-\delta IC(U)$  but  $S \cap T = \{w_3\}$  is not in  $Ng-\delta IC(U)$ .

**Theorem 4.9.** In an INTS,  $S \cap H$  is Ng- $\delta I$ -closed whenever  $S$  is Ng- $\delta I$ -closed and  $H$  is N- $\delta I$ -closed.

**Proof.** Let  $S \cap H \subseteq W$  and  $W \in \mathbb{N}(U)$ . Then  $S \subseteq W \cup (U - H)$  where  $U - H \in \mathbb{N}(U)$ , since N- $\delta I$ -open. Therefore,  $W \cup (U - H)$  is an N-open set. Since  $S$  is Ng- $\delta I$ -closed,  $Ncl_{\delta I}(S) \subseteq W \cup (U - H)$ . Therefore,  $Ncl_{\delta I}(S) \cap H \subseteq W$ . Therefore,  $Ncl_{\delta I}(S \cap H) \subseteq W$ .

**Theorem 4.10.** For  $S \subseteq U$  in an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,  $S$  is Ng- $\delta I$ -closed if and only if  $Ncl_{\delta I}(S) \subseteq Nker(S)$ .

**Proof.** Necessity: If  $x \notin Nker(S)$ , then there is a  $W \in \mathbb{N}(U)$  containing  $S$  and  $x \notin W$ . There is a contradiction to  $x \in Ncl_{\delta I}(S)$ , since  $S$  is Ng- $\delta I$ -closed. Therefore,  $Ncl_{\delta I}(S) \subseteq Nker(S)$ .  
 Sufficiency: Let  $S \subseteq W$  and  $W \in \mathbb{N}(U)$ . Then  $Nker(S) \subseteq W$ . Hence,  $Ncl_{\delta I}(S) \subseteq W$ .

**Theorem 4.11.** For a N- $\Lambda$ -set  $S$  of an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,  $S$  is Ng- $\delta I$ -closed if and only if  $U - S \in N-T_{\delta I}$ .

**Proof.** Necessity: Suppose  $S$  is Ng- $\delta I$ -closed. By Theorem 4.10,  $Ncl_{\delta I}(S) \subseteq Nker(S) = S$ , since  $S$  is a N- $\Lambda$ -set. Hence,  $U - S \in N-T_{\delta I}$ .  
 Sufficiency: Since  $S$  is N- $\delta I$ -closed the proof holds by Theorem 3.2.

**Theorem 4.12.** For  $S \subseteq U$  in an INTS  $(U, \mathbb{N}, \mathcal{J})$ , if  $Nker(S)$  is Ng- $\delta I$ -closed then  $S$  is also Ng- $\delta I$ -closed.

**Proof.** Let  $S \subseteq W$  and  $W \in \mathbb{N}(U)$ . Then  $Nker(S) \subseteq W$ . Hence,  $Ncl_{\delta I}(Nker(S)) \subseteq W$  by assumption. But  $Ncl_{\delta I}(S) \subseteq Ncl_{\delta I}(Nker(S))$ . Therefore,  $S$  is Ng- $\delta I$ -closed.  
 Corollary 4.13 and Corollary 4.14 holds whenever  $I = \{\phi\}$  and  $I = P(U)$  respectively in Theorem 4.12.

**Corollary 4.13.** For  $S \subseteq U$  in an NTS  $(U, \mathbb{N})$ , if  $Nker(S)$  is N- $\delta g$ -closed then  $S$  is also N- $\delta g$ -closed.







**Palani and Karthigai jothi**

**Corollary 4.14.** For  $S \subseteq U$  in an NTS  $(U, \mathbb{N})$ , if  $Nker(S)$  is Ng-closed then  $S$  is also Ng-closed.

**Theorem 4.15.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,  $S$  is a Ng- $\delta$ I-closed subset of  $U$  and  $S \subseteq T \subseteq Ncl_{\delta}(S)$ , then  $T$  is also Ng- $\delta$ I-closed.

**Proof.**  $Ncl_{\delta}(T) - T \subseteq Ncl_{\delta}(S) - S$ , and since  $S$  is Ng- $\delta$ I-closed, by Theorem 4.1,  $Ncl_{\delta}(S) - S$  has no nonempty N-closed subset and so  $Ncl_{\delta}(T) - T$  also does not contain any nonempty N-closed subset. Therefore, again by Theorem 4.1,  $T$  is Ng- $\delta$ I-closed.

**Theorem 4.16.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$  the given below statements are equivalent for any  $S \subseteq U$ :

- (i)  $S$  is Ng- $\delta$ I-closed.
- (ii)  $S \cup (U - Ncl_{\delta}(S))$  is Ng- $\delta$ I-closed.
- (iii)  $Ncl_{\delta}(S) - S$  is Ng- $\delta$ I-open.

**Proof.** (i) $\Rightarrow$ (ii). Let  $S \cup (U - Ncl_{\delta}(S)) \subseteq W$  and  $W \in \mathbb{N}(U)$ . Then  $U - W \subseteq U - (S \cup (U - Ncl_{\delta}(S))) = Ncl_{\delta}(S) - S$ .  $U - W = \emptyset$  by (i) and Theorem 4.1. Therefore  $U = W$ . Since  $S \cup (U - Ncl_{\delta}(S)) \subseteq U$ ,  $S \cup (U - Ncl_{\delta}(S))$  is Ng- $\delta$ I-closed.  
 (ii)  $\Rightarrow$  (i). Suppose  $S \cup (U - Ncl_{\delta}(S))$  is Ng- $\delta$ I-closed. Let  $H \subseteq Ncl_{\delta}(S) - S$  and  $H$  is N-closed, then  $S \cup (U - Ncl_{\delta}(S)) \subseteq U - H$ . Since  $U - H \in \mathbb{N}(U)$ ,  $Ncl_{\delta}(S \cup (U - Ncl_{\delta}(S))) \subseteq U - H$  implies  $Ncl_{\delta}(S) \cup Ncl_{\delta}(U - Ncl_{\delta}(S)) \subseteq U - H$ . Therefore  $U \subseteq U - H$  and so  $H = \emptyset$ . Hence by Theorem 4.1,  $S$  is Ng- $\delta$ I-closed.  
 Since  $U - (Ncl_{\delta}(S) - S) = S \cup (U - Ncl_{\delta}(S))$ , (ii) and (iii) are equivalent.  
 Corollary 4.17 and Corollary 4.18 holds whenever  $I = \{\emptyset\}$  and  $I = P(U)$  respectively in Theorem 4.16.

**Corollary 4.17.** In an NTS  $(U, \mathbb{N})$ , the statements given below are equivalent for any  $S \subseteq U$ :

- (i)  $S$  is N- $\delta$ g-closed.
- (ii)  $S \cup (U - Ncl_{\delta}(S))$  is N- $\delta$ g-closed.
- (iii)  $Ncl_{\delta}(S) - S$  is N- $\delta$ g-open.

**Corollary 4.18.** In an NTS  $(U, \mathbb{N})$ , the statements given below are equivalent for any  $S \subseteq U$ :

- (i)  $S$  is Ng-closed.
- (ii)  $S \cup (U - Ncl(S))$  is Ng-closed.
- (iii)  $Ncl(S) - S$  is Ng-open.

**Theorem 4.19.** For  $S, T \subseteq U$  in an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,

- (i) If  $S \subseteq T \subseteq Ncl_{\delta}(S)$  then,  $Ncl_{\delta}(S) = Ncl_{\delta}(T)$ .
- (ii)  $Ncl_{\delta}(S)$  is always Ng- $\delta$ I-closed for any  $S \subseteq U$ .

**Proof.** (i) By Lemma 2.4, the proof hold.  
 (ii) Let  $Ncl_{\delta}(S) \subseteq W$  where  $W \in \mathbb{N}(U)$ . Since  $Ncl_{\delta}(Ncl_{\delta}(S)) = Ncl_{\delta}(S)$ , we have  $Ncl_{\delta}(Ncl_{\delta}(S)) \subseteq W$  whenever  $Ncl_{\delta}(S) \subseteq W$  and  $W \in \mathbb{N}(U)$ . Hence,  $Ncl_{\delta}(S)$  is Ng- $\delta$ I closed.

**Theorem 4.20.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,  $U = U_{Nc} \cup U_{Ng-\delta I}$ , where  $U_{Nc} = \{x \in U : \{x\} \text{ is N-closed}\}$  and  $U_{Ng-\delta I} = \{x \in U : \{x\}^c \text{ is Ng-}\delta\text{I-closed}\}$ .

**Proof.** If  $x \notin U_{Nc}$  then  $U$  alone contains  $\{x\}^c$ . Hence,  $x \in U_{Ng-\delta I}$ .

**Theorem 4.21.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,  $U_k \cap Ncl_{\delta}(S) \subseteq Nker(S)$ , for any subset  $S \subseteq U$ , where  $U_k = \{x \in U : \{x\} \subseteq Nint(Ncl^*(\{x\}))\}$ .

**Proof.** Let  $x \in U_k \cap Ncl_{\delta}(S)$  and  $x \notin Nker(S)$ . Since  $x \in U_k$ ,  $Nint(Ncl^*(\{x\})) \neq \emptyset$ . Also since  $x \in Ncl_{\delta}(S)$ ,  $S \cap Nint(Ncl^*(W)) \neq \emptyset$  for any  $W \in W_N(x)$ . Therefore  $S \cap Nint(Ncl(W)) \neq \emptyset$ , for any  $W \in W_N(x)$ . Choose  $W = Nint(Ncl(\{x\}))$ . Then  $S \cap Nint(Ncl(\{x\})) \neq \emptyset$ . Choose  $y \in S \cap Nint(Ncl(\{x\}))$ . Since  $x \notin N-\Lambda(S)$ , there is a  $W \in \mathbb{N}(U)$  such that  $S \subseteq W$  and  $x \notin W$ . If





### Palani and Karthigai jothi

$H=U-W$ , then  $H$  is an  $N$ -closed set such that,  $x \in H \subseteq U - S$ . Also,  $Nint(Ncl(\{x\})) \subset Nint(Ncl(H)) \subset Ncl(H) = H$  and hence  $y \in S \cap H$ , a contradiction. Thus,  $x \in Nker(S)$ . In an INTS a proper nonempty  $Ng-\delta I$ -closed set  $S \subseteq U$  is known as maximal  $Ng-\delta I$ -closed if  $U$  and  $S$  are the only two  $Ng-\delta I$ -closed sets containing  $S$ . Generally, every maximal  $Ng-\delta I$ -closed set is  $Ng-\delta I$ -closed. But the given below Example reveals that the reverse direction is not true. In Example 3.4 (ii),  $S = \{w_1\}$  is  $Ng-\delta I$ -closed but not maximal  $Ng-\delta I$ -closed.

**Theorem 4.22.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$ ,

- (i)  $H \cup W = U$  or  $W \subseteq H$  whenever  $H$  is maximal  $Ng-\delta I$ -closed and  $W$  is  $Ng-\delta I$ -closed.
- (ii)  $H \cup W = U$  or  $H = W$  whenever  $H$  and  $W$  be maximal  $Ng-\delta I$ -closed.

**Proof.** (i) If  $H \cup W = U$ , then the proof is over. Suppose,  $H \cup W \neq U$ . By Theorem 4.10,  $H \cup W \in Ng-\delta IC(U)$ . We have  $H \cup W = U$  or  $H \cup W = H$  since  $H$  is a maximal  $Ng-\delta I$ -closed set. Hence,  $H \cup W = H$  and so  $W \subseteq H$ .

(ii) If  $H \cup W = U$ , then the proof completes. Suppose,  $H \cup W \neq U$ . Then by (i),  $H \subseteq W$  and  $W \subseteq H$ . Hence  $H = W$ .

**Theorem 4.23.** In an INTS  $(U, \mathbb{N}, \mathcal{J})$  a subset  $S \in Ng-\delta IO(U)$  if and only if  $H \subseteq Nint_{\delta I}(S)$  whenever  $H$  is  $N$ -closed and  $H \subseteq S$ .

**Proof.** Necessity: Let  $S \in Ng-\delta IO(U)$  and  $H$  be an  $N$ -closed set contained in  $S$ . Then

$U-S \subseteq U-H$  and hence  $Ncl_{\delta I}(U-S) \subseteq U-H$ . Thus  $H \subseteq U - Ncl_{\delta I}(U-S) = Nint_{\delta I}(S)$ .

Sufficiency: Suppose  $U-S \subseteq W$  where  $W$  is  $N$ -open. Then,  $U-W \subseteq S$  and  $U-W$  is  $N$ -closed. Then  $U-W \subseteq Nint_{\delta I}(S)$  which implies  $Ncl_{\delta I}(U-S) \subseteq W$ . Consequently,  $U - S \in Ng-\delta IO(U)$  and so  $S \in Ng-\delta IO(U)$ .

**Theorem 4.24.** If  $S \in Ng-\delta IO(U)$  and  $Nint_{\delta I}(S) \subseteq T \subseteq S$ , then  $T \in Ng-\delta IO(U)$  in  $(U, \mathbb{N}, \mathcal{J})$ .

**Proof.** Suppose  $H \subseteq T$  where  $H$  is  $N$ -closed set of  $(U, \mathbb{N}, \mathcal{J})$ . Then,  $H \subseteq S$ . Since  $S \in Ng-\delta IO(U)$ , by Theorem 4.23,  $H \subseteq Nint_{\delta I}(S)$ . Since  $Nint_{\delta I}(S) \subseteq Nint_{\delta I}(T)$ , we have  $H \subseteq Nint_{\delta I}(T)$ . Therefore again by Theorem 4.23,  $T \in Ng-\delta IO(U)$ .

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**Palani and Karthigai jothi**

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## *In vitro* Antioxidant and Anti-Inflammatory Potential of *Clematis wightiana* Wall. ex Wight & Arn.: A Wild Medicinal Plant

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### ABSTRACT

*Clematis wightiana* well-known medicinal plant of Ranunculaceae family is used by many tribal groups to treat inflammation in India. In the study, different extracts such as petroleum ether, chloroform, ethyl acetate, ethanol and water of *C. wightiana* leaf and stem are evaluated for its antioxidant and anti-inflammatory activity. Among various extracts, leaf ethyl acetate extracts showed the maximum amount of phenolics (252.63 mg GAE/g extract), tannin (244.18 mg GAE/g extract) and flavonoids ethyl acetate stem (164.40 mg RE/g extract) content. It also revealed the presence of highest antioxidant property by estimating DPPH% (IC<sub>50</sub>: 23.25 µg/mL), ABTS stem (42916.7 µM TE/g extract), Superoxide leaf (71.61%) radical scavenging activity and Phosphomolybdenum ethyl acetate (644.96 mg AAE/g). The leaf ethyl acetate extract showed high degree of inhibition (80.57%) in anti-inflammatory assay. *Piper wightii* leaf extracts have a tremendous amount of antioxidant potential, making them a good source of natural antioxidant supplements for food to protect against oxidative stress-related diseases, including inflammation.





Vishnu Kumar et al.,

**Keywords:** Antioxidant, Anti-inflammatory, *Clematis wightiana*

## INTRODUCTION

Plants have been used for centuries as a primary source of pharmacologically active compounds due to their wide range of applications and relatively low toxicity in biological systems [1, 2]. Drug discovery and development have been the primary areas of attention in the centuries-long study of medicinal plants and natural products [3]. Novel pharmaceuticals rely heavily on the identification of bioactive chemicals. Almost sixty percent of all pharmaceuticals currently on the market may trace their roots back to nature [4]. Drugs derived from plants have been used successfully to treat a wide variety of illnesses, including those affecting the skin, the digestive system, the nervous system, the circulatory system, the lungs, the liver, the kidneys, the blood, and the central nervous system; these illnesses range [5]. Antioxidants' biological properties such as anti-allergic, anti-atherogenic, anti-inflammatory, hepato-protective, antimicrobial, antiviral, antibacterial, anti carcinogenic, antithrombotic, cardio protective, and vasodilatory-make them essential [6, 7]. Plant-derived antioxidants prevent oxidative stress-related illnesses. Oxidative stress is caused by a ROS-antioxidant defence system imbalance [8]. Oxidative stress causes free radicals to damage proteins, lipids, and nucleic acids, compromising cell health and leading to cancer [9], atherosclerosis, diabetes, cardiovascular disease, ageing, and inflammatory diseases [10]. This puts human health at risk. Plant secondary metabolites neutralize free radicals, scavenge oxygen, and decompose peroxides to stabilize oxidative damage [7]. Anti-inflammatory phyto medicine is very essential. Inflammation is a complex process that begins when the body is wounded by mechanical or chemical substances in a self-destructive manner. In many inflammatory illnesses, phagocytes create free radicals that increase vascular permeability, protein denaturation, and membrane modification [11]. Antioxidants and anti-inflammatory drugs work together to stop inflammation and oxidative stress.

Antioxidants made in a lab and pain relievers that don't include steroids are both commonplace today. Natural antioxidants are in high demand, but this is because these substances pose a significant health risk. Hence, as an alternative to synthetic pharmaceuticals, researchers all over the world are looking for novel antioxidant and anti-inflammatory medications that don't have those side effects. Polyphenolic compounds are widely employed as safe natural antioxidants, and they include phenolic acids, vitamins (atocopherols, ascorbic acid), and other chemicals [12]. The absence of inflammation and oxidative stress in people's bodies is mostly due to the non-nutritional substances that provide these protections. You can find phenolic and non-phenolic chemicals in both food and non-edible plants, not just medicinal ones. This study examines *Clematis wightiana* extract phytochemicals and antioxidant properties. Ranunculaceae includes *C.wightiana*. The family has 60 genera and 2,200 woodies, climbing vines. Ranunculaceae are found worldwide, mostly in temperate Northern hemisphere regions. *Clematis*, the second-largest genus in the family, with 355 species. Phyllotaxy (opposite leaves) and habit (viney) distinguish the *Clematis* genus [13]. Traditional medicine has relied on clematis species for several diseases. *Clematis* is anti-cancer, antibacterial, anti-inflammatory, and analgesic, according to early studies [14]. Folk medicine treats rheumatism, indigestion, headaches, varicose veins, bone disorders, nasal congestion, and sinusitis using *C.wightiana* [15, 16]. *C. wightiana* is utilized in folk medicine for its therapeutic benefits, although no scientific investigations support these claims. So, this study determined the phyto chemical profile, quantified secondary metabolites, and tested *C. wightiana* component extracts for antioxidant and anti-inflammatory activities.

## MATERIALS AND METHODS

Authentication of the plant material was validated by the Botanical Survey of India, Southern Regional Centre in Coimbatore, Tamil Nadu. The fresh leaves of *Clematis wightiana* were collected in the Coonoor rural areas. One kilogrammes of the plant were dried in the shade between 25 and 30 ° C for 7 days. The pulverized results of the dried leaves. Soxhlet extraction was used on the powdered plant material with petroleum ether, chloroform, ethyl acetate, ethanol, and water. The extracts were lyophilized into powder form after being evaporated with a rotary



**Vishnu Kumar et al.,**

evaporator. The following formula was used to get the yield %.  $\text{Yield (g/100 g)} = (W_1/100)/W_2$  Where  $W_1$  is the weight of the extract residue after the solvent has been removed, and  $W_2$  is the weight of the plant powder used in the extractor.

**Determination of total phenolic**

Total phenolics were quantified using the Folin-Ciocalteu technique, with gallic acid standing as the standard equivalent (in mg/g). A volume of 100  $\mu\text{l}$  of the diluted sample extracts was mixed using 500  $\mu\text{l}$  of the Folin-Ciocalteu reagent (Merck, Germany). Sodium carbonate (2.5%) was added after 3 or 5 mins, and the mixture was left to sit for 30 minutes at room temperature. Spectro photometric analysis of absorbance at 765 nm [17].

**Determination of total tannin**

Tannins were extracted and analyzed polyvinyl polypyrrolidone treatment (PVPP). A 100 mg 12 mm eppendr of tube was filled with 100 mg of PVPP, 500 mL of distilled water, and 500 mL of the sample extracts. For 4 hours, the contents were stored in the refrigerator at 4°C [18].

**Determination of Flavonoid**

Total flavonoid content was determined using a spectro photometric method based on formation of their complexes with Al (III). 1 mL of a sample was mixed with 0.3 mL of  $\text{NaNO}_2$  (5%, w/v) and after 5 min 0.5 mL of  $\text{AlCl}_3$  (2%, w/v) was added. A sample was mixed and six minutes later was neutralized with 0.5 mL of 1 mol/L NaOH solution. The mixture was left for 15 min at room temperature and then absorbance was measured at 510 nm. The results were expressed as Rutin Equivalent (RE) in mg per gram fresh weight of leaf and stem. Absorbance was measured in three replications [19].

**IN VITRO ANTIOXIDANT ACTIVITY****Evaluation of antioxidant activity (DPPH)**

The antioxidant activity was measured by free radical scavenging with 2,2-diphenyl-1-picrylhydrazyl (DPPH). Absorbance at 517 nm measured radical scavenging [20]. The relative radical scavenging activity (%) was determined as  $[1 - \text{absorbance of solution with sample and DPPH} / \text{absorbance with DPPH}] \times 100$ .

**ABTS radical scavenging assay**

ABTS radical cations were generated by reacting a 7 mM ABTS solution with a potassium per sulphate solution (2.45 mM). Before use, the solution was diluted with distilled water to achieve  $0.700 \pm 0.005$  absorbance at 734 nm. 30  $\mu\text{L}$  of the sample was added to 3 mL of ABTS solution at ambient temperature. The absorbance at 734 nm was obtained after 6 min. The standard curve was prepared using Trolox solution, and total antioxidants were reported as mmol of Trolox equivalents per 100 g of dry weight [21].

**Superoxide radical scavenging assay**

Superoxide radical production using the PMS-NADH system. In a PMS-NADH system, NADH oxidation generates superoxide radicals that reduce NitroblueTetrazolium (NBT). In this experiment, superoxide radicals were produced in 3 ml of Tris-HCl buffer (16 mM, pH 8.0) with 78 mM NADH, 50 mM NBT, 10 mM PMS, and samples at various concentrations. The colour reaction between superoxide radicals and NBT was monitored at 560 nm by a Milton Roy Spectronic 3000 spectrophotometer. Control was L-ascorbic acid [22]. Scavenging activity (%) =  $[(\text{Control OD} - \text{Sample OD}) / \text{Control OD}] \times 100$

**Phosphomolybdate assay (Total antioxidant capacity)**

The fractions' total antioxidant capacity was measured using phosphomolybdate and ascorbic acid. A 0.1-ml sample solution aliquot was combined with 1 ml reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). Capped tubes were incubated in a 95°C water bath for 90 min. After cooling to room temperature, the mixture's absorbance was measured at 765 nm against a blank. A typical blank was incubated







Vishnu Kumar et al.,

under the same circumstances with 1 ml of the reagent solution and the appropriate solvent [23]. Standard ascorbic acid. The antioxidant capacity was estimated using following formula:

Antioxidant effect (%) = [(control absorbance - sample absorbance) / (control absorbance)] \* 100

#### **In vitro Anti-inflammatory Activity**

##### **Membrane Stabilization Method**

2% dextrose, 0.8% sodium citrate, 0.05% citric acid, and 0.42% sodium chloride were dissolved in distilled water to create Alsever's solution, which was then sterilized [24]. The amount of haemoglobin in the supernatant solution was estimated by spectro photometry to be 560 nm. The following formula was used to figure out how much activity there was in stabilizing membranes:

$$\text{Percentage inhibition} = \frac{\text{Control} - \text{Treated sample}}{\text{Control}} \times 100$$

#### **Statistical analysis**

Data were analyzed by SPSS software using analysis of variance (ANOVA) and differences among means were determined for significance at  $P < 0.05$  using Tukey's test.

## **RESULTS AND DISCUSSION**

#### **Quantification of Secondary metabolites**

##### **Quantification of total phenolics**

Polyphenols are good metal chelators and free radical scavengers due to their numerous hydroxyl groups [25]. Antioxidant responses depend on hydroxyl group arrangement around the phenolic molecule [26]. The increased solubility of phenolics and other fragrance components in leaf and stem ethyl acetate extracts may explain their higher phenolic content. Several plant species have shown that total phenolics can boost antioxidant capability [27]. The amount of total phenolics of different extracts of leaf and stem of *C. wightiana* were analyzed and are presented in table 1. The total phenolics were found to be higher in ethyl acetate extract of leaf (252.63 mg GAE/g extract), Followed by hot water extract (207.89 mg GAE/g extract). The ethanol extracts of leaf and stem showed higher phenolic content compared to all the other solvent extracts.

##### **Quantification of tannins**

The solvent extracts obtained from soxhlet apparatus of leaf and stem of *C. wightiana* were analyzed for its tannin content and the results are shown in table 1. The tannin contents were found to be higher in ethyl acetate and hot water extracts of leaf 244.18 and 189.45 mg GAE/g extract respectively. For their astringent qualities, tannins are used in a number of pharmaceuticals. They are a helpful remedy for the throat and may be used to treat haemorrhoids, diarrhoea, dysentery, and leucorrhoea [28].

##### **Quantification of flavonoids**

Flavonoids are phenolics with the largest variety and importance. Flavonoids reduce heat or chemical-induced lipid peroxidation and chelate metallic and super oxide ions in food preparation [29]. Flavonoids block molecular oxygen ( $O_2$ ), scavenging free radicals, according to [30]. (anti-oxidant). Flavonoids also scavenge OH and  $NO_2$  radicals [31]. Table 1. Summarized that the flavonoid content in analysed leaf and stem of *C. wightiana* varied widely and ranged from (43.04 to 164.40 mg RE/g). Ethyl acetate extract of Stem (164.40 mg RE/g) showed the highest amount of flavonoid contents. Flavonoids are known to be synthesized by plants in response to microbial infection; hence, it should not be astonishing that they have been found *in vitro* to be effective antimicrobial substances against a wide array of microorganisms.





### **In vitro Antioxidant Assays**

#### **DPPH radical scavenging activity**

The DPPH radical is frequently used to test substances as free radical scavengers or hydrogen donors to assess the antioxidant activity of plant extracts and meals [32]. Phenolics contribute to *C.australe* extracts' antiradical scavenging and electron transfer/hydrogen donating abilities [33]. DPPH inhibition and IC<sub>50</sub> of *C. wightiana* leaf and stem plant extracts at various doses (µg/mL). Fig. 1 shows the average free radical scavenging activity of leaf and stem of *C. wightiana* cultivars using DPPH assay. This demonstrated considerable differences across extracts. Ethyl acetate (23.25 µg/mL) had the highest DPPH assay scavenging activity, whereas *C. wightiana* stem petroleum ether had the lowest antioxidant activity (257.88 µg/mL). Fig. 1 shows the DPPH radical scavenging assay findings for *C. wightiana* samples and standards including rutin and BHT. Antioxidant hydrogen donation scavenged the DPPH radical, decreasing its absorption. Purple turns yellow. Antioxidant activity increases with decreasing IC<sub>50</sub> (Inhibitory concentration at 50%).

#### **ABTS radical cation scavenging activity**

The TEAC (Trolox Equivalents Antioxidant Capacity) was measured using ABTS radical cation de colourisation assay, one of the most frequently employed methods for antioxidant capacity. The results were expressed as µmol Trolox/g dry weight of plant material. The results of ABTS radical cation scavenging activities of different parts of *C. wightiana* leaf and stem extracts were shown in table 2. The *C. wightiana* stem Ethyl acetate extract showed higher ABTS+ scavenging activity (42916.7 µM TE/g extract) when compared to the other solvent extracts. The Chloroform of *C. wightiana* leaf showed lower radical scavenging activity (15833.33 µM TE/g extract). The ABTS radical-scavenging activities of different parts of *C. wightiana* samples along with standards such as Rutin, and BHT were determined by the ABTS radical cation scavenging assay and the results are shown in table 2. Antioxidants inhibit the long-lived blue/green chromophore ABTS radical cation, which absorbs at 734 nm. This radical's water-solubility and strong absorption coefficient at long wavelengths make it easy to measure its consumption rate without interference [34].

#### **Superoxide radical scavenging activity**

The results of superoxide anion scavenging activities of different extracts of *C. wightiana* leaf and stem are shown in table 2. The results showed that Ethyl acetate extract of leaves (71.61%) have highest radical scavenging activity compared with other solvent extracts of other parts of the plant. Among the different extracts of leaf, significant activity was shown by ethanol extract (67.53%). The lower scavenging activity was noticeable in chloroform extract of *C. wightiana* stem (40.89%). The results were compared with natural (rutin) and synthetic (BHT) antioxidants. Superoxide radical damages cells by forming reactive oxygen species [35]. Superoxide radical creates hydrogen peroxide, hydroxyl, and singlet oxygen, therefore scavenging it is crucial [36]. Many biological activities generate damaging superoxide radical. Even though superoxide radical anions cannot directly cause lipid oxidation, their scavenging is important because they generate highly reactive species like hydroxyl radical [37].

#### **Phosphomolybdenum assay**

The total antioxidant capacity of different solvent extracts of leaf and stem of *C. wightiana* were analyzed and shown in Fig 2. Among different parts used, leaf showed higher activity in most of its solvents compared to the extracts of stem. Ethyl acetate extract of leaf (644.96mg AAE/ g extract) have highest phosphomolybdenum reduction compared to other solvent extracts. The lower antioxidant capacities of the different parts of extracts were found to range from 190.46 to 644.96mg AAE/g extract. The phosphomolybdenum method is based on the reduction of Mo(VI) to Mo(V) by the antioxidant compounds and the subsequent formation of green phosphate/Mo(V) complex at acidic pH with the maximal absorption at 695 nm [38].

### **In vitro Anti-Inflammatory activity**

#### **Membrane stabilization assay**

The anti-inflammatory activities were expressed in percentage inhibition of leaf and stem extracts of *C. wightiana* were shown in Fig. 3. Among the various extracts leaf ethyl acetate extracts of *C. wightiana* (80.57%) showed



**Vishnu Kumar et al.,**

higher inhibition activity. Anti-inflammatory activity of the different extracts as follows as ethyl acetate > ethanol > hot water > chloroform > petroleum ether. During the inflammation, lysis of lysosomal membrane takes place where it releases enzyme components that produce various disorders [39]. NSAID either inhibits the release of lysosomal enzymes or stabilize the lysosomal membrane [40]. When RBC is exposed to injurious substances (hypotonic medium, heat, methyl salicylate and phenyl hydrazine) the lysis of the RBC membrane takes place with hemolysis and oxidation of haemoglobin [41]. Since human RBC membranes are similar to lysosomal membranes, the inhibition of hypotonicity and heat induced lysis are taken as measures to study the mechanism of anti-inflammatory activity [42]. Values are mean of triplicate determination (n=3) ± standard deviation, statistically significant at  $p < 0.05$  where [a>b>c>d]

**CONCLUSION**

The *C. wightiana* leaf ethyl acetate extract showed high antioxidant and anti-inflammatory activities. The global trend towards non-toxic herbal products necessitates the development of safer *C. wightiana* medications for inflammation-related disorders. Isolation, identification, and characterisation of active chemical components will help researchers understand bioactive goods and manage illness in the future.

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**Table 1: Phenolic, Tannin and flavonoids content of *C. wightiana* Leaf and Stem**

Sample	Extracts	Phenolic GAE/g extract	Tannin GAE/g extract	Flavonoids RE/100 g
Leaf	Petroleum ether	52.04 ± 1.33	49.46 ± 1.77	79.30 ± 1.29
	Chloroform	33.04 ± 1.82	32.17 ± 1.68	43.04 ± 1.16
	Ethyl acetate	<b>252.63 ± 1.75<sup>a</sup></b>	<b>244.18 ± 2.21<sup>a</sup></b>	149.44 ± 2.38 <sup>b</sup>
	Ethanol	185.67 ± 1.33 <sup>c</sup>	170.35 ± 0.88 <sup>c</sup>	94 ± 0.2 <sup>d</sup>
	Hot Water	207.89 ± 1.75 <sup>b</sup>	189.45 ± 2.38 <sup>b</sup>	119.51 ± 0.2 <sup>c</sup>
Stem	Petroleum ether	31.28 ± 1.33	30.51 ± 1.66	83.65 ± 0.35
	Chloroform	61.11 ± 1.33	56.7 ± 1.21	81.95 ± 2.04
	Ethyl acetate	144.15 ± 2.2 <sup>d</sup>	140.05 ± 2.47 <sup>d</sup>	<b>164.40 ± 2.50<sup>a</sup></b>
	Ethanol	46.19 ± 1.01	39.26 ± 0.49	43.18 ± 0.7
	Hot Water	89.47 ± .87	82.14 ± 1.18	68.42 ± 0.23

Values are mean of triplicate determination (n=3) ± standard deviation, statistically significant at  $p < 0.05$  where <sup>a>b>c>d</sup> in each column:

**Table 2. ABTS scavenging activity and Superoxide radical *C. wightiana* Leaf and stem**

Sample	Extracts	ABTS scavenging Activity (µM TE/g extract)	Superoxide radical scavenging activity Percentage of Inhibition (%)
Leaf	Petroleum ether	24513.89 ± 60.14	58.61 ± .56
	Chloroform	15833.33 ± 813.56	45.35 ± 1.37







Vishnu Kumar et al.,

	Ethyl acetate	38888.89 ± 262.14 <sup>c,d</sup>	71.61 ± 0.57 <sup>b</sup>
	Ethanol	27152.78 ± 1661.23	67.53 ± 1.27 <sup>c</sup>
	Hot Water	28680.56 ± 1510.71	61.37 ± .99
Stem	Petroleum ether	22152.8 ± 433.68	60.01 ± 2.21
	Chloroform	36006.9 ± 1503.52	40.89 ± 1.59
	Ethyl acetate	42916.7 ± 360.84 <sup>b</sup>	65.23 ± 1.41 <sup>d</sup>
	Ethanol	40034.7 ± 216.84 <sup>c</sup>	55.02 ± 1.41
	Hot Water	37395.8 ± 375.57 <sup>d</sup>	51.13 ± 2.07
Standards	Rutin	70208.33 ± 208.33 <sup>a</sup>	74.7 ± 0.25 <sup>a,b</sup>
	BHT	70798.61 ± 318.23 <sup>a</sup>	74.2 ± 0.1 <sup>a</sup>

Values are mean of triplicate determination (n = 3) ± standard deviation, TE- Trolox Equivalents, statistically significant at p <0.05 whereas <sup>a>b>c>d</sup>in each column

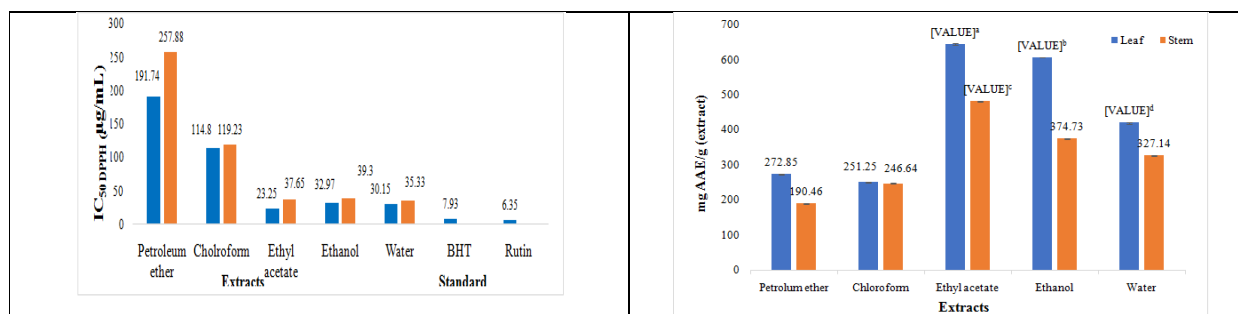


Fig 1: DPPH radical scavenging activity of *C. wightiana* Leaf and stem

Fig 2: Phosphomolybdenum Assay of *C. wightiana* Leaf and stem Extracts

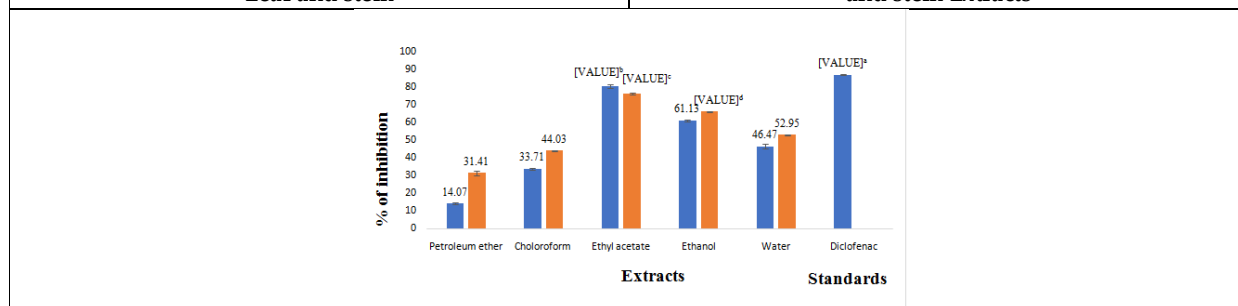


Fig 3. In vitro Anti-Inflammatory activity of *C. wightiana* Leaf and stem Extracts







## Alteration in Biotic and Abiotic Components of Environment Due to Iron Stress and Its Management for Sustainable Ecosystem: A Review

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### ABSTRACT

The contamination heavy metals chain almost always follows cyclic order in the environment like a biogeochemical cycle from biotic to abiotic component and vice versa. Exposure of heavy metals and metalloids at low levels are very common and cause the adverse effects on environment. Heavy metal toxicity is regarded as major threat and there are various health risks associated with it. Metal toxicity depends on the route of exposure and duration of the exposure and its dose. Iron occurs naturally in lithosphere in the form of different types rock. It also deposited in surface water bodies and ground water through leaching. Iron can be present in two forms; the soluble ferrous iron or the insoluble ferric iron. Water that contain ferrous iron is clear and colorless, and when exposed to air it turns cloudy causing a reddish brown precipitate of ferric iron appears. It is an essential trace element for maintenance of energy metabolism. It can be found in food, such as eggs; red meat; and beans, peas, and other legumes. The present recommended limit for iron in drinking water is 0.3 mg/l. Iron is essential for healthy body, for normal functions like the intestines reduce the absorption of mineral from food and drink to prevent its levels from rising too high but excessive consumption of iron causes different disorders. The body cannot excrete the extra iron fast enough, so it continues to build up. The body stores it in organ tissue, mainly in the liver, as well as the heart and the pancreas. There are several types of iron overload disorder. This paper is a collective review paper that is specially focused on of iron pollution at



**Nibedita Badajena et al**

local level, national level and global level, impacts of iron on different components of environment and its remediation by using different methodologies.

**Keywords:** iron, stress, toxicity, local, national, global, impacts, environment

**INTRODUCTION**

Iron poisoning is one of the most common toxic ingestion and one of the deadliest among children [1]. Iron is one of the common and second most abundant metal in the earth. It is found in lithosphere as well as in different water bodies. Elemental iron is rarely found in nature, as the ferrous ions and Ferric ions readily combine with oxygen- and sulfur-containing compounds to form oxides, hydroxides, carbonates, and sulfides. Iron is most commonly found in nature in the form of its oxides [2]. In surface water, such as rivers and lakes, dissolved iron is hardly ever found, because it reacts with oxygen, forms insoluble compounds. Through leaching, it also reaches to the ground water as a most common dissolved heavy metal. Although in small concentration not considered to cause health problems in humans, its presence in water is rather unpleasant due to its rusty colour, its tendency to stain clothing. The presence of dissolved iron also enhances the growth of a kind of iron bacteria, which forms dark-coloured slime layers on the inner side of pipes which ultimately reaches to the food chain. This review paper aims to identify the iron rich areas, impacts of iron on both biotic and abiotic components of environment and its remediation.

**Source of iron pollution in Environment****Iron pollution in Global level [3]**

The world's top five iron ore mining countries are Australia (900 million tonnes), Brazil (400 million tonnes), China (340 million tonnes), India (230 million tonnes), Russia (95 million tonnes) accounted for more than 80% of global production in 2020. The occurrence of iron in water bodies specially in ground water is a direct result of its leaching from surface soil or water bodies and natural existence in underground rock formations. As the earth's underground rock formations contains about 5% iron it is common to find iron in many of the geographical area around the world. Most countries have accepted a safe drinking water standard (aesthetic, not health related) with a maximum of 0.3 ppm iron concentration. At the same time, iron is an essential element for humans, with a recommended daily intake of 5 milligrams per litre. Therefore, the environment agencies in many countries have established a secondary limit for iron in drinking water, which is based on concerns of Secondary Maximum Contaminant Level (SMCL). In countries such as the US, India Canada, Greece, Iran, Russia and others, the SMCL for iron in drinking water is 0.3 mg/L (milligrams per litre) or ppm (parts per million) [4].

**Iron pollution in National level**

Iron & steel is considered as one of the driving force behind development of industry. Iron & Steel Industry plays an important role to influences a country's economic status. India is among the leading producers of most important iron ores of hematite ( $\text{Fe}_2\text{O}_3$ ) and magnetite ( $\text{Fe}_3\text{O}_4$ ) in the world. About 79% hematite ore deposits are found in the Easternmost states of India (Assam, Bihar, Chhattisgarh, Jharkhand, Odisha & Uttar Pradesh) while about 93% magnetite ore deposits occur in Southernmost states of India (Andhra Pradesh, Goa, Karnataka, Kerala, & Tamil Nadu). Karnataka alone contributes maximum amount (72%) of magnetite deposit in India. Due to higher grade hematite is considered to be superior among other iron ores. Magnetite is another principal iron ore that also occurs in the form of oxide, either in igneous or metamorphosed banded magnetite-silica formation. As per NMI database based on UNFC system, the total reserves of magnetite ore have been estimated at 10,789 million tonnes. On the basis of grades of ore, it shows 20% resources are of Metallurgical grade while 80% resources are considered as Unclassified, Unknown and Coal Washery. 98% magnetite reserves/resources of India are located in five States, namely, Karnataka (7,802 million tonnes or 72% reserves) followed by Andhra Pradesh (1,392 million tonnes or 13%), Rajasthan (617 million tonnes or 6%), Tamil Nadu (507 million tonnes or 5%) and Goa (226 million tonnes or 2%). Assam, Bihar, Chhattisgarh, Jharkhand, Kerala, Maharashtra, Meghalaya, Nagaland, Odisha and Telangana together account for the remaining 2% resources [5, 6].



**Nibedita Badajena et al****Iron pollution in local level**

In Odisha, Keonjhar is considered to be the mining hub because it occupies a total of 64 mining projects. Drinking water is the basic problems faced by local people. Due to deposition of iron on surface water bodies, it turns into Orange-colored water. Water in mining areas are not suitable for consumption. The water could be used for irrigation, but was not fit for domestic purposes such as drinking, bathing or washing clothes.

**Impacts of iron toxicity in plants**

Iron is considered as an essential element for plant life cycle, but in excess amount it affects adversely on plant growth and metabolism. It also affects during plant respiration, photosynthesis and causes oxidative toxicity [7]. Sometimes it also causes oxidative burst [8, 9]. Plants act both as “accumulators” and “excluders”. Accumulators survive despite concentrating contaminants in their aerial tissues. They biodegrade the contaminants into inert forms in their tissues whereas excluders restrict contaminant uptake. when present at low ppm Plants have evolved highly specific and very efficient mechanisms to obtain essential micronutrients from the surroundings. Even from nearly insoluble precipitates, from very low levels in the soil plant roots aided by plant-produced chelating agents and plant induced pH changes and redox reactions, are able to solubilize. Plants have also evolved in the mechanisms to translocate and store micronutrients. These same mechanisms are also involved in the uptake, translocation storage of toxic elements. Thus, micronutrient uptake mechanisms are of great interest to phyto remediation [10].

**Impacts of Iron toxicity on animals**

Iron is one of the most crucial element for growth and survival of almost all living organisms [11]. Due to the inter conversion between ferrous ( $Fe^{+2}$ ) and ferric ( $Fe^{3+}$ ) ions, iron is main transition metal for biological redox processes. Source of iron in the surface water is anthropogenic and is mostly related to mining activities [12]. In ocean, dissolved iron concentration is normally  $33.5 \times 10^{-9}$  mg/L or 0.6 nM. Its concentration is low in freshwater and very high in ground water [13]. In some countries people have been exposed to high levels of iron in drinking water when collected groundwater exceeded the permissible limit [14]. Precipitation of iron will cause significant damage by hindering respiration through clogging action in fishes [15]. The growth of aquatic species on iron toxicity was found to be inhibited by the concentration of 1 mg/L. [12]. Iron is also found as trace element in the body and is essential in functioning of most biological system. It is considered as intracellular toxin as it exerts toxic effects on mitochondria by shutting electrons away from the electron transport chain [16].

**Mechanism of iron toxicity**

Iron is failing to bind with the proteins leads to the formation of various harmful free radicals. Due to these free radical's concentration of iron is severely affected gastrointestinal tract and biological fluids. Due to the excessive iron level in the body the rate limiting absorption step also saturated and this free iron easily penetrates into the cells of vital organs like liver, heart and brain. Conversion of Ferrous to ferric iron takes place and after the disruption of oxidative phosphorylation, hydrogen ions releases from this ferric iron that increase the metabolic activity. Free iron can also lead to the lipid peroxidation, which results in the severe damage to mitochondria, micro some and other organelles of the cell [17]. These free radicals also result in cellular damage, mutations in DNA which intern causes different types of diseases [18].

**Impacts of Iron toxicity on humans**

Iron poisoning in adult are found rarely but most of the cases are found in children [19, 20] as they are maximum exposed to iron products [21] and very few in older age groups [22, 23]. Iron toxicities also leads to formation of gastrointestinal ulcerations [24]. Free radicals are the cause for lung cancer because asbestos associated cancer is linked to free radicals [25]. Iron salts are considered to be safe by the food and drug administration as their concentration as well as dose both are very much low [26].



**Nibedita Badajena et al****Impacts of iron on Environment****Impacts of iron on atmosphere**

In remote areas, iron levels in air are 50–90  $\mu\text{g}/\text{m}^3$ ; at urban sites, levels are about 1.3  $\mu\text{g}/\text{m}^3$ . Concentration levels up to 12  $\mu\text{g}/\text{m}^3$  have been reported in the degraded of iron- and steel producing plants [27]. Iron particles are having heavy mass. Due to its high weight it is not found largely in atmospheric air. So it has no more adverse impact on atmosphere. One of the study suggested that acute and chronic exposures specifically to iron-rich airborne nanoparticles, which are abundant in the urban environment, constitute a plausible, pervasive risk factor for cardiac mitochondrial dysfunction and subsequent CVD development, from earliest childhood [28].

**Impacts of iron on hydrosphere**

The iron concentration in rivers has permissible limit 0.7 mg/litre. In anaerobic groundwater where iron is in the form of iron(II), concentrations will usually be 0.5–10 mg/litre, but concentrations up to 50 mg/litre can sometimes be found. Concentrations of iron in drinking-water are less than 0.3 mg/litre but may be higher in countries where various iron salts are used as coagulating agents in water-treatment plants and where cast iron, steel, and galvanized iron pipes are used for water distribution. Due to mining of iron ore, nearby surface water bodies are found to be directly polluted with iron due to surface runoff. The colour of surface water become changes and turned red colour found to be unsuitable for domestic use.

**Iron in food**

Iron occurs as a natural constituent in plants and animals. Liver, kidney, fish, and green vegetables contain 20–150 mg/kg, whereas red meats and egg yolks contain 10–20 mg/kg, Rice and many fruits and vegetables have low iron contents (1–10 mg/kg). As iron is considered as an essential food at low concentration. So the food items containing iron can be consumed. Reported daily intakes of iron in food: the major source of exposure is ranging from 10 to 14 mg. Drinking-water containing 0.3 mg/litre would contribute about 0.6 mg to the daily intake. Iron intake from air is about 25  $\mu\text{g}/\text{day}$  in urban areas [29].

**Control measure of iron pollution**

Handling and wind erosion from storage pile and contribute to the atmospheric pollution. The polluting emissions in the iron and steel industry are controlled by a variety of evacuation systems, devices, and methods such as cyclone cleaners, dry or wet electrostatic precipitators, scrubbers, bag houses, hoods, furnace enclosures; chemical, catalytic and biological methods. Apart from this there is another environment friendly way to remediate iron pollution from soil and water bodies are phyto remediation.

**Phytoremediation**

This is a bioremediation process that employs varieties of plants to eliminate, transfer, maintain, extract or degrade contaminants in the soil. There are different types of phyto remediation mechanisms that are used to degrade contaminants from soil and water bodies like Rhizosphere biodegradation, Phyto stabilization, Phyto extraction, Rhizofiltration, Phyto volatilization and Phyto degradation.

**Hyper-accumulators of iron**

Hyper-accumulators are unusual plants that accumulate particular metals in their living tissues [30]. Hyper accumulators should be having an anti-herbivore defenses, allelopathy and biotic interactions abilities [31] and practical applications in bio fortification [32]. Hyper accumulator plants appear to restricted in their distribution to metalliferous soils, from which they exhibit hyperaccumulation of some element; these are described as 'obligate' hyper accumulators [33] some are more widespread, with populations that hyper accumulate from metalliferous soils, and other populations, from nonmetalliferous soils, that do not show unusual accumulation; these are 'facultative' hyperaccumulators [34]. Heavy metal contaminated soils and water pose an increasing problem to human and animal health. Using plants that hyper accumulate specific metals in cleanup efforts appeared over the last 20 years. Metal accumulating species can be used for phytoremediation (removal of contaminant from soils) or phytomining (growing plants to harvest the metals). In addition, as many of the metals that can be hyper



**Nibedita Badajena et al**

accumulated are also essential nutrients, food fortification and phyto remediation might be considered two sides of the same coin. In contrast, *hyperaccumulators* are plants which, when exposed to elevated concentrations of heavy metals, are able to accumulate them in their ground parts without phyto toxicity symptoms. Iron concentration in plant tissues follows the order of root > stem > leaf [35]. Water jasmín is used to purify the iron contaminated waste water [36]. Free floating macrophytes were also reported as hyper accumulator of iron [37]. Different hydrophytes such as *Salvinia cucullata*, *Pistia stratiotes*, *Lemna minor* and *Eichornia crassipes* for phyto remediation of iron [38] (Singh and Rai, 2016). *Lemna* is also used to remove iron from mine effluents [39] (Taixeira et. al., 2014). In another study [40] Chaturvedi et. al, (2012) reported phyto stabilization potential of *Alexandrian laurel* and reported safe survival of plant with 100% survivability rate. In another experiment on 24 willow clones for enhancing phyto remediation efficiency of iron [35]. *Hibiscus cannabinus* L. also reported for remediation of iron from land fill leachates [41]. Some leguminous plants are also reported as iron accumulating plants [42]. Similarly, Sun flower plant was also reported as hyperaccumulator of iron [43]. Phytoremediation potential of *Cyperus esculentus*, *Typha angustifolia* in mixed metal solution including iron has been studied and *Typha* was found to be best accumulator among them [44].

**CONCLUSION**

After going through a number of research work, case studies and other reports, it was observed that the iron is one of the essential element for survival of organisms as well as human beings but at higher concentration, it has adverse effects on the environment as well as living organisms. Effective legislation, guidelines and detection of the areas where there are higher levels of heavy metals are necessary. Failure to control the exposure will result in severe complications in the future because of the adverse effects imposed by higher concentration of iron. National as well as international co-operation is also needed to control the iron pollution. Further studies should be carried out to remediate the iron pollution by different methodologies like extraction of useful iron materials to reduce the pollution load from the polluted site.

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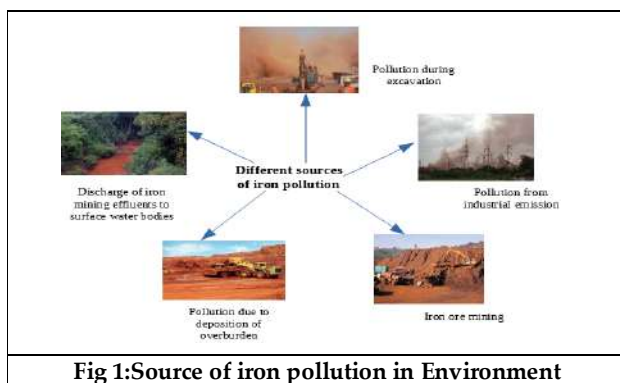


Fig 1:Source of iron pollution in Environment

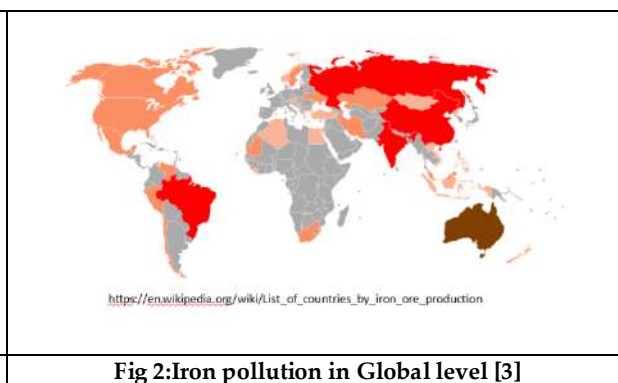


Fig 2:Iron pollution in Global level [3]





## Inhibition Effect of Black Seed (*Nigella sativa* L. ) Extract against *Listeria monocytogenes* and *Vibrio cholerae*

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### ABSTRACT

Black seed (*Nigella sativa*.L) is a wonder plant commonly known as Black Cumin is a herbaceous plant of Ranunculaceae family, growing in countries Eastern Europe, the Middle East, and Western Asia. Black seed oil, extract and plant has been used for thousands of years as a spice, condiment, carminative, food preservative, as well as a protective and curative treatment for numerous disorders in traditional and Indian folk medicine. The black seeds normally contain 36-38% fixed oil, proteins, alkaloids, saponins, and essential oils making up rest of the composition. In India it is commercially cultivated in West Bengal, Punjab, Jharkhand, Himachal Pradesh, Bihar and Assam. Small scale cultivation is also taken at Uttar Pradesh, Rajasthan, Madhya Pradesh and Tamil Nadu states. India is known to be the largest producer of *Nigella* in the world. Black seed oil has been shown to be effective against a wide spectrum of organisms- bacteria like *Listeria monocytogenes* and *Vibrio cholerae*. Agar well diffusion method was followed to determine the antimicrobial activity of Blackseed in different solvent extract.

**Keywords:** Black seed, Extract, Antimicrobial, Well diffusion



Usharani *et al.*,

## INTRODUCTION

Black seed (*Nigella sativa*L), is wonder plant commonly known as Black Cumin /Kalonji/ Kalajira is a herbaceous plant of Ranunculaceae family, growing in countries Eastern Europe, the Middle East, and Western Asia (Fararhet *et al.*, 2004). Black seed oil, extract and plant has been used for thousands of years as a spice, condiment, carminative, food preservative, as well as a protective and curative treatment for numerous disorders in traditional and Indian folk medicine (Nair *et al.*, 2005). The black seeds normally contain 36-38% fixed oil, proteins, alkaloids, saponins, and essential oils making up rest of the composition (Burtis and Bucar, 2000). Although the properties of black seed extract or oil showed antimicrobial activity (Morsi, 2000), antifungal (Khan *et al.*, 2003), antioxidant activity (Khalife and Lupidi, 2008), antitumor activity (Worthen *et al.*, 1998), and a stimulatory effect on the immune system (Salem and Hossain, 2000). In India it is commercially cultivated in West Bengal, Punjab, Jharkhand, Himachal Pradesh, Bihar and Assam. Small scale cultivation is also taken at Uttar Pradesh, Rajasthan, Madhya Pradesh and Tamil Nadu states. India is known to be the largest producer of *Nigella* in the world.

The other producing countries are Sri Lanka, Bangladesh, Nepal, Egypt, Iraq and Pakistan. It is estimated to be produced in an area of about 9000 ha with the production of about 7000–8000 tons in India (Huchchannanavaret *et al.*, 2019). The flowers are delicate, and usually coloured pale blue and white, with 5-10 petals. The fruit is a large and inflated capsule composed of 3–7 united follicles, each containing numerous seeds. *Nigella* seeds are small, black grains with a rough surface and an oily white interior. They are roughly triangulate, 1 1/2 - 3 mm (1/16 to 1/8 inch) long and resembles to onion seeds. The seeds have little bouquet, though when they are rubbed, they give off an aroma. These seeds give slightly bitter and peppery flavour with a crunchy texture. *Nigella sativa*Lhas been extensively in use for centuries in folk medicines, both as herb and for oil by people in Asia, Middle East and Africa for medicinal purposes. Seeds are used as a new source of edible oils and food applications as spices and condiments in cakes, breads, pastries, curries, pickles and in seasoning etc.

Among Muslims, it is regarded as one of the greatest forms of healing medicine available. Recent pharmacological investigations have proved the potential therapeutic effects of *Nigella* seed as well as its oil (Tariq, 2008). *Nigella sativa*Lhas been used as herbal medicine for more than 2000 years. Also used as a food additive and flavour in many countries. The oil of *Nigella sativa*Lis so beneficial due to its content of over a hundred active components. Two thousand years ago the *Nigella sativa*Lhas been traditionally used by various cultures as a natural remedy to treat numerous diseases. (Krishnakantet *et al.*, 2010) The seeds of the plant are used in Southeast Asia, Middle and Far East as a natural remedy to treat many diseases including asthma, hypertension, diabetes, hypercholesterolemia, inflammation, arthritis, tumour, gastrointestinal disturbances and gynaecological disorders for over 2000 years (Ramadan, 2007). Recently, clinical and animal studies have shown that extract of the black seeds have many therapeutic effects such as immunomodulate (Hanafy and Hatem, 1991), hypotensive (Turkdoganet *et al.*, 2001), hepatoprotective (Kanter *et al.*, 2003) and antidiabetic effects (Houghton *et al.*, 1995). Hence Holy Prophet Muhammad (Peace be upon him) said, “The black seed (Kalonji) is the remedy for every disease except death” (Bukhari *et al.*, 1985).

## MATERIALS AND METHODS

### Extraction of volatile oil from the black seeds

Steam distillation of the crushed black seed affords the volatile (v.o) content as an aqueous fraction from which the v.o is isolated by simple extraction with diethyl ether followed by evaporation of the organic layer under reduced pressure. The v.o. content of *Nigella sativa*Lhas been determined to be 0.4% - 0.5% w/w (Hashim and El-Kiey,1962, El-Alfyetal., 1975).

### Preparation of plant extracts

**Chemicals** The present study for the preparation of *Nigella sativa*L extract the following chemicals were used Ethyl acetate, Methanol, Acetone.

### Extract Storage





Usharani et al.,

After extraction sample was stored in an amber glass screwcap bottle at room temperature until use.

#### Cultures used

The micro organisms for the study were collected from the department of microbiology, Annamalai University. They were subcultured and used for antimicrobial activity studies. The microorganisms used for this study were *Listeria monocytogenes* and *Vibrio cholerae*.

#### Antibacterial activity of *Nigella sativa*.L

Agar well diffusion method was followed to determine the antimicrobial activity of Blackseed in different solvent extract. Each bacterial isolate was suspended in nutrient broth and diluted approximately to  $10^5$  colony forming units (CFU) per ml. they were flood inoculated onto the surface of nutrient agar and then dried. Five-millimetre diameter wells were cut from the agar using a sterile cork-borer, and 200 $\mu$ l of the sample solutions of different concentrations 250 ppm, 500ppm, and 1000ppm were delivered into the wells. The plates were incubated for 2 days at 37°C antibacterial activity was evaluated by measuring the zone of inhibition against the test organisms.

## RESULTS AND DISCUSSION

#### Inhibition effect of Black seed (*Nigella sativa*.L) extract against *Listeria monocytogenes*

The inhibition effect of Black seed Extract was tested against *Listeria monocytogenes* and the values obtained in the present research results were furnished in Table- 1. Among the different concentrations viz., 250 ppm, 500 ppm, 1000 ppm of different solvent extracts of Black seed were tested against *Listeria monocytogenes* among of which 1000 ppm produced highest inhibitory activity against *Listeria monocytogenes* the inhibitory effect was directly proportional to concentration of the plant extracts tested. The maximum area of inhibition zone was observed 8.30 mm in the Ethyl acetate at 1000 ppm it was followed by methanol extract at 1000ppm and recorded inhibition zone of 7.5 mm. There is no zone formation in Acetone extract of blackseed at 1000ppm.

#### Inhibition effect of Black seed (*Nigella sativa*.L) extract against *Vibrio cholerae*

The inhibition effect of Black seed Extract was tested against *Vibrio cholerae* and the values obtained in the present research results were furnished in Table- 2. Among the different concentrations viz., 250 ppm, 500 ppm, 1000 ppm of different solvent extracts of Black seed were tested against *Vibrio cholerae* among of which 1000 ppm produced highest inhibitory activity against *Vibrio cholerae* the inhibitory effect was directly proportional to concentration of the plant extracts tested. The maximum area of inhibition zone was observed 13.3 mm in the Ethyl acetate at 1000 ppm it was followed by methanol extract at 1000ppm and recorded inhibition zone of 11.5 mm. The zone formation in Acetone extract of black seed at 1000ppm recorded the 11.00 mm.

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Table : 1 Inhibition effect of Black seed (*Nigella sativa*.L) extract against *Listeria monocytogenes*

S.No	Extracts	Diameter of Inhibition zone(mm)		
		Concentration in PPM		
		100	150	250
1.	Ethyl acetate	7.2	7.7	8.3
2.	Methanol	6.4	7.0	7.5
3.	Acetone	0	0	0

Table : 2 Inhibition effect of Black seed (*Nigella sativa*.L) extract against *Vibrio cholerae*

S.No	Extracts	Diameter of Inhibition zone(mm)		
		Concentration in PPM		
		100	150	250
1.	Ethyl acetate	7.2	10.7	13.3
2.	Methanol	6.4	9.0	11.5
3.	Acetone	6.2	8.7	11





## On Picture Fuzzy Ideals of Semi Groups

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### ABSTRACT

In this paper, we have proposed the notion of picture fuzzy ideals of semigroup and also additionally established the properties with suitable examples. The concept of picture fuzzy sub-semigroup, picture fuzzy left (resp.right) ideal, picture fuzzy bi-ideal, picture fuzzy interior ideal is dealt with suitable illustration. Theorems were proposed and proved based totally on picture fuzzy sub-semi groups, picture fuzzy left (resp right) ideal, picture fuzzy bi-ideal, pictures fuzzy interior ideal. By the concepts of semi organizations, the results may be tried with more accuracy for picture fuzzy ideals as opposed to intuitionistic fuzzy ideals. An illustrative instance has been explained for picture fuzzy sub-semigroups respective bi-ideals and interior deals of semigroups.

**Keywords:** Picture fuzzy sub-semi group, picture fuzzy ideal, picture fuzzy bi-ideal and picture fuzzy in terior ideal.

### INTRODUCTION

Zadeh [23] defined the concept of fuzzy subsets or fuzzy sets as a function from a non empty set  $X$  to the unit interval  $[0, 1]$  in 1965. Then, Rosenfeld [19] proposed the concept of fuzzy groups, which was the first inspired application to various algebraic structures. Later, the concept of fuzzy sub-semi groups was also suggested by Kuroki [12, 15]. He also studied the concept of fuzzy generalized bi-ideals in semigroups, which is an extension of the concept of fuzzy bi-ideals and used fuzzy left ideals and fuzzy right ideals to characterize particular classes of semigroups (see, [13, 14]). Yiarayong [21] characterized regularities of semigroups by the properties of their hesitant fuzzy ideals. Subsequently, Gatetem and Khamrot [7] studied the characterizations of regular, left (resp. right) regular, intra regular, weakly regular and quasi- regular semi groups by using

70735







### Hema and Anitha

bipolar fuzzy weakly interior ideals. As a generalization of the notion of fuzzy sets, Atanassov [2,3] created the concept of intuitionistic fuzzy sets as follows. An intuitionistic fuzzy set  $A$  on a universe  $X$  is an object of the form  $A = \{(x, \mu_A(x), \eta_A(x)) \mid x \in X\}$  where  $\mu_A(x) \in [0,1]$  and  $\eta_A(x)$  denote the degree of membership and the degree of non-membership, respectively, for each  $x \in X$  to the set  $A$ , and so  $\mu_A(x) + \eta_A(x) \leq 1$  for all  $x \in X$ . We can see that the fuzzy sets define the degree of membership of an element in a given set, while the intuitionistic fuzzy sets provide both membership and non- membership degrees. The concept of intuitionistic fuzzy sets was applied to semi groups by Kim and Jun [11] in 2002. Later, theorems characterizing intra-regular semi groups in terms of intuitionistic fuzzy left ideals, intuitionistic fuzzy right ideals and intuitionistic fuzzy bi-ideals were presented by Hong and Fang [8]. In addition, the class of regular semigroups was described by Hur et. al., [10] using intuitionistic fuzzy left, right, two-side bi-ideals and intuitionistic fuzzy bi-ideals of semi groups. Moreover, Shabir and Khan [20] have characterized intra-regular ordered semigroups by properties of their intuitionistic fuzzy interior ideals. Subsequently, Cuong and Kreinovich [5] first introduced the notion of picture fuzzy sets in 2013, as direct generalizations of the concepts of fuzzy sets and intuitionistic fuzzy sets. This concept has been investigated by various mathematicians, see, e.g., [1,9,17,16,24]. Recently, Yiarayong [21,22] has applied the notion of picture fuzzy sets to semi group theory and used picture fuzzy left (resp. right) ideals and picture fuzzy bi-ideals of semi groups to characterize different classes regular and intra regular semi groups. In 2021, Nakkhasen [18] studied some further characterizations of regular and intra-regular semi groups in terms of picture fuzzy left (resp. right) ideals, picture fuzzy quasi-ideals and picture fuzzy (resp. generalized) bi-ideals of semi groups. In this article, the aim of this study is to establish and discuss their suited properties by using defining picture fuzzy ideals of semi groups and picture fuzzy (left or proper) ideals of semi groups have been attempted to derive the neutrality belongings based totally at the concept defined by using Chinnadurai and Arulselvam [4].

#### Preliminaries

In this section, some basic fuzzy set, intuitionistic fuzzy set and picture fuzzy set has been reviewed.

**Definition 2.1** Let  $S$  be a semigroup.

1. Let  $M$  and  $N$  be subsets of  $S$ , the product of  $M$  and  $N$  is defined as
2.  $MN = \{mn \in S \mid m \in M \text{ and } n \in N\}$
3. A non-empty subset  $M$  of  $S$  is called a sub-semigroup of  $S$ , if  $MM \subseteq M$ .
4. A non-empty subset  $M$  of  $S$  is called a left (resp. right) ideal of  $S$  if  $SM \subseteq M$  (resp.  $MS \subseteq M$ ).
5.  $M$  is called a two sided ideal of  $S$  if it is both a left ideal and right ideal of  $S$ .
6. A sub-semi group  $M$  of  $S$  is called a bi-ideal of  $S$  if  $MSM \subseteq M$ .
7. A sub-semi group  $M$  of  $S$  is called a (1,2) ideal of  $S$  if  $MSM^2 \subseteq M$ .

By a fuzzy set  $\mu$  in a non-empty set  $S$ , we mean a function  $\mu: S \rightarrow [0,1]$ , and the complement of  $\mu$ , denoted by  $\bar{\mu}$ , is the fuzzy set in  $S$  is given by  $\bar{\mu}(x) = 1 - \mu(x)$  for all  $x \in S$ .

#### Fuzzy set [1]

Fuzzy set is a set in which every element has degree of membership of belonging in it. Mathematically, let  $X$  be a universal set. Then the fuzzy subset  $A$  of  $X$  is defined by its membership function  $\mu_A: X \rightarrow [0, 1]$  which assign a real number  $\mu_A(x)$  in the interval  $[0, 1]$ , to each element  $x \in A$ , where the value of  $\mu_A(x)$  at  $x$  shows the grade of membership of  $x$  in  $A$ .

#### Intuitionistic fuzzy set [2]

A Intuitionistic fuzzy set  $P$  on a universe of discourse  $X$  is of the form

$$P = \{(z, \zeta_P(z), \gamma_P(z)) \mid z \in X\}$$

Where  $\zeta_P(z) \in [0, 1]$  is called the "degree of membership of  $z$  in  $P$ ",  $\gamma_P(z) \in [0, 1]$  is called the "degree of non-membership of  $z$  in  $P$ ", and where  $\zeta_P(z)$  and  $\gamma_P(z)$  satisfy the following condition:  $0 \leq \zeta_P(z) + \gamma_P(z) \leq 1$  for all  $z \in X$ . The amount  $\pi_A(x) = 1 - (\zeta_P(z) + \gamma_P(z))$  is called the hesitancy of  $x$  which is reflection of lack of commitment or uncertainty associated with the membership or non-membership or both in  $P$ .

**Definition 2.2** Let  $X$  be a universe of discourse, A Pythagorean fuzzy set (PFS)





Hema and Anitha

$$P = \{(z, \vartheta_p(z), \omega_p(z)) / z \in X\}$$

where  $\vartheta_p(z) \in [0,1]$  represent the degree of membership of  $z$  in  $P, \omega_p(z) \in [0,1]$ , non-membership of the object  $z \in X$  to the set  $P$  subject to the condition  $0 \leq (\vartheta_p(z))^2 + (\omega_p(z))^2 \leq 1$  for all  $z \in X$ . For the sake of simplicity, a PFS is denoted as  $P = (\vartheta_p(z), \omega_p(z))$ .

**Definition 2.3** Let  $X$  be a universe of discourse, A Picture fuzzy set (PFS)

$$P = \{(z, \zeta_p(z), \eta_p(z), \gamma_p(z)) / z \in X\}$$

where  $\zeta_p(z): X \rightarrow [0,1], \eta_p(z): X \rightarrow [0,1]$  and  $\gamma_p(z): X \rightarrow [0,1]$  represent the degree of memberships, non-membership and hesitancy of the object  $z \in X$  to the set  $P$  subject to the condition  $0 \leq \zeta_p(z) + \eta_p(z) + \gamma_p(z) \leq 1$  for all  $z \in X$ . For the sake of simplicity, a PFS is denoted as  $P = (\zeta_p(z), \eta_p(z), \gamma_p(z))$ .

**Picture fuzzy ideals of semi groups**

In this section, the definition of Picture fuzzy (PF)sub-semi groups, PF left (resp. right)ideal, PFBI, PFIntI based the given definitions theorems have been discussed. Let  $S$  be a semi group unless otherwise specified.

**Definition 3.1** A Picture fuzzy set (PFS) $P = (\zeta_p, \eta_p, \gamma_p)$  in  $S$  is called a Picture fuzzy sub-semigroup of  $S$ , if it satisfies

1.  $\zeta_p(x_1x_2) \geq \min\{\zeta_p(x_1), \zeta_p(x_2)\}$
2.  $\eta_p(x_1x_2) \leq \max\{\eta_p(x_1), \eta_p(x_2)\}$
3.  $\gamma_p(x_1x_2) \leq \max\{\gamma_p(x_1), \gamma_p(x_2)\}$  for all  $x_1, x_2 \in S$ .

**Definition 3.2** A Picture fuzzy set (PFS) $P = (\zeta_p, \eta_p, \gamma_p)$  in  $S$  is called a Picture fuzzy left ideal of  $S$ , if

1.  $\zeta_p(x_1x_2) \geq \zeta_p(x_2)$
2.  $\eta_p(x_1x_2) \leq \eta_p(x_2)$
3.  $\gamma_p(x_1x_2) \leq \gamma_p(x_2)$  for all  $x_1, x_2 \in S$ .

A Picture fuzzy right ideal of  $S$  is defined an analogous way. A  $P_iFSP = (\zeta_p, \eta_p, \gamma_p)$  in  $S$  is called a Picture fuzzy ideal of  $S$ , if it is both a Picture fuzzy left and Picture fuzzy right ideal of  $S$ . It is clear that any Picture fuzzy left (resp. right) ideal of  $S$  is a Picture fuzzy sub-semigroup of  $S$ .

**Example 3.1** Let  $(S, \cdot)$  be a semi group where  $S = \{a, b, c, d\}$ , the cayley table for  $S$  is defined as follows.

Thus, a Picture fuzzy set  $P = (\zeta_p, \eta_p, \gamma_p)$  in  $S$ .

**Example 3.2** Suppose Picture fuzzy set  $P = (\zeta_p, \eta_p, \gamma_p)$  in  $S$  as follows.

We have  $S = \{a, b\}$  be a subset. Let  $x_1 = a$  and  $x_2 = b$  in definition 3.1. Take LHS

$$\zeta_p(x_1x_2) = \zeta_p(ab) = 0.3. \text{ Then RHS } \min\{\zeta_p(a), \zeta_p(b)\} = \min\{0.3, 0.2\} = 0.2. \text{ Therefore}$$

$\zeta_p(x_1x_2) \geq \min\{\zeta_p(x_1), \zeta_p(x_2)\}$ . Similarly, we calculate other conditions also. It is true for all the subsets of  $S$ . Thus

$P = (\zeta_p, \eta_p, \gamma_p)$  is a Picture fuzzy sub - semigroup of  $S$ .

**Definition 3.3** A Picture fuzzy set  $P = (\zeta_p, \eta_p, \gamma_p)$  of  $S$  is called a Picture fuzzy bi-ideal (PFBI) of  $S$ , if

1.  $\zeta_p(x_1ux_2) \geq \min\{\zeta_p(x_1), \zeta_p(x_2)\}$
2.  $\eta_p(x_1ux_2) \leq \max\{\eta_p(x_1), \eta_p(x_2)\}$
3.  $\gamma_p(x_1ux_2) \leq \max\{\gamma_p(x_1), \gamma_p(x_2)\}$  for all  $u, x_1, x_2 \in S$ .

**Example 3.3** Define a Picture fuzzy set  $P = (\zeta_p, \eta_p, \gamma_p)$  in  $S$  as follows.

Since by definition 3.3

1.  $\zeta_p(x_1ux_2) \geq \min\{\zeta_p(x_1), \zeta_p(x_2)\} \quad 0.3 \geq 0.1.$
2.  $\eta_p(x_1ux_2) \leq \max\{\eta_p(x_1), \eta_p(x_2)\} \quad 0.2 \leq 0.2$
3.  $\gamma_p(x_1ux_2) \leq \max\{\gamma_p(x_1), \gamma_p(x_2)\} \quad 0.3 \leq 0.5$  Similarly we check all the subsets of  $S$  also.

Thus  $P = (\zeta_p, \eta_p, \gamma_p)$  is Picture fuzzy bi-ideal of  $S$ .

**Theorem 3.1** If  $\{P_i\}_{i \in I}$  is a family of Picture fuzzy bi – ideals of (PFBI) of  $S$ , then  $\cap P_i$  is a PFBI of  $S$ , where

$\cap P_i = (\wedge \zeta_{P_i}, \wedge \eta_{P_i}, \vee \gamma_{P_i})$  and  $\wedge \zeta_{P_i}, \wedge \eta_{P_i}, \vee \gamma_{P_i}$  are defined as follows.

$$\wedge \zeta_{P_i} = \inf\{\zeta_{P_i}(x_1) | i \in I, x_1 \in S\},$$

$$\wedge \eta_{P_i} = \sup\{\eta_{P_i}(x_1) | i \in I, x_1 \in S\},$$

$$\vee \gamma_{P_i} = \sup\{\gamma_{P_i}(x_1) | i \in I, x_1 \in S\}.$$





Hema and Anitha

*Proof.* Let  $x_1, x_2 \in S$ . Then we have  $\wedge \zeta_{P_i}(x_1x_2) \geq \inf \{ \min\{\zeta_{P_i}(x_1), \zeta_{P_i}(x_2)\} \}$   
 $= \inf \{ \min\{\zeta_{P_i}(x_1), \min\{\zeta_{P_i}(x_2)\} \}$   
 $= \min\{\inf(\zeta_{P_i}(x_1)), \inf(\zeta_{P_i}(x_2))\}$   
 $\wedge \eta_{P_i}(x_1x_2) \leq \sup \{ \max\{\eta_{P_i}(x_1), \eta_{P_i}(x_2)\} \}$   
 $= \sup \{ \max\{\eta_{P_i}(x_1), \max\{\eta_{P_i}(x_2)\} \}$   
 $= \max\{\sup(\eta_{P_i}(x_1)), \sup(\eta_{P_i}(x_2))\}$   
 $\vee \gamma_{P_i}(x_1x_2) \leq \sup \{ \max\{\gamma_{P_i}(x_1), \gamma_{P_i}(x_2)\} \}$   
 $= \sup \{ \max\{\gamma_{P_i}(x_1), \max\{\gamma_{P_i}(x_2)\} \}$   
 $= \max\{\sup(\gamma_{P_i}(x_1)), \sup(\gamma_{P_i}(x_2))\}$ .

Hence  $\cap P_i$  is a Picture fuzzy sub-semigroup of  $S$ .

Next for  $u, x_1, x_2 \in S$ , we obtain

$$\zeta_{P_i}(x_1ux_2) \geq \inf \{ \min\{\zeta_{P_i}(x_1), \zeta_{P_i}(x_2)\} \}$$

$$= \inf \{ \min\{\zeta_{P_i}(x_1), \min\{\zeta_{P_i}(x_2)\} \}$$

$$= \min\{\inf(\zeta_{P_i}(x_1)), \inf(\zeta_{P_i}(x_2))\}$$

$$\wedge \eta_{P_i}(x_1ux_2) \leq \sup \{ \max\{\eta_{P_i}(x_1), \eta_{P_i}(x_2)\} \}$$

$$= \sup \{ \max\{\eta_{P_i}(x_1), \max\{\eta_{P_i}(x_2)\} \}$$

$$= \max\{\sup(\eta_{P_i}(x_1)), \sup(\eta_{P_i}(x_2))\}$$

$$\vee \gamma_{P_i}(x_1ux_2) \leq \sup \{ \max\{\gamma_{P_i}(x_1), \gamma_{P_i}(x_2)\} \}$$

$$= \sup \{ \max\{\gamma_{P_i}(x_1), \max\{\gamma_{P_i}(x_2)\} \}$$

$$= \max\{\sup(\gamma_{P_i}(x_1)), \sup(\gamma_{P_i}(x_2))\}$$
.

Hence  $\cap P_i$  is a PFBI of  $S$ . Hence the proof.

**Theorem 3.2** Every Picture fuzzy left (resp. right) ideal of  $S$  is a Picture fuzzy bi-ideal of  $S$ .

**Proof:** In this proof of the theorem definition 3.2 and definition 3.3 are used. Let  $P = (\zeta_P, \eta_P, \gamma_P)$  be a Picture fuzzy left ideal of  $S$  and  $u, x_1, x_2 \in S$ .

Then

$$\zeta_P(x_1ux_2) = \zeta_P(x_1ux_2)$$

$$\geq \zeta_P(x_2)$$

$$\zeta_P(x_1ux_2) \geq \min\{\zeta_P(x_1), \zeta_P(x_2)\}$$

$$\eta_P(x_1ux_2) = \eta_P(x_1ux_2)$$

$$\leq \eta_P(x_2)$$

$$\eta_P(x_1ux_2) \leq \max\{\eta_P(x_1), \eta_P(x_2)\}$$

$$\gamma_P(x_1ux_2) = \gamma_P(x_1ux_2)$$

$$\leq \gamma_P(x_2)$$

$$\gamma_P(x_1ux_2) \leq \max\{\gamma_P(x_1), \gamma_P(x_2)\}$$

Thus  $P = (\zeta_P, \eta_P, \gamma_P)$  is PFBI of  $S$ . The Picture fuzzy right ideal is proved in an analogous way.

**Theorem 3.3** Every Picture fuzzy bi-ideal of a group  $S$  is constant.

**Proof:** Let  $P = (\zeta_P, \eta_P, \gamma_P)$  be a PFBI of a group  $S$  and let  $x_1 \in S$ .

Then

$$\zeta_P(x_1) = \zeta_P(ex_1e)$$

$$\geq \min\{\zeta_P(e), \zeta_P(e)\} \text{ (Since by def.3.3)}$$

$$= \zeta_P(e)$$

$$= \zeta_P(ee)$$

$$= \zeta_P(x_1x_1^{-1})(x_1x_1^{-1})$$

$$= \zeta_P(x_1(x_1^{-1}x_1^{-1})x_1)$$

$$\geq \min\{\zeta_P(x_1), \zeta_P(x_1)\}$$

$$= \zeta_P(x_1)$$





**Hema and Anitha**

$$\begin{aligned} \eta_P(x_1) &= \eta_P(ex_1e) \\ &\leq \max\{\eta_P(e), \eta_P(e)\} \\ &= \eta_P(e) \\ &= \eta_P(ee) \\ &= \eta_P(x_1x_1^{-1})(x_1x_1^{-1}) \\ &= \eta_P(x_1(x_1^{-1}x_1^{-1})x_1) \\ &\leq \max\{\eta_P(x_1), \eta_P(x_1)\} \\ &= \eta_P(x_1) \end{aligned}$$

and

$$\begin{aligned} \gamma_P(x_1) &= \gamma_P(ex_1e) \\ &\leq \max\{\gamma_P(e), \gamma_P(e)\} \\ &= \gamma_P(e) \\ &= \gamma_P(ee) \\ &= \gamma_P(x_1x_1^{-1})(x_1x_1^{-1}) \\ &= \gamma_P(x_1(x_1^{-1}x_1^{-1})x_1) \\ &\leq \max\{\gamma_P(x_1), \gamma_P(x_1)\} \\ &= \gamma_P(x_1), \text{ here } e \text{ is the identity of } S. \end{aligned}$$

It follows that  $\zeta_P(x_1) = \zeta_P(e)$ ,  $\eta_P(x_1) = \eta_P(e)$  and  $\gamma_P(x_1) = \gamma_P(e)$  this means that  $P = (\zeta_P, \eta_P, \gamma_P)$  is constant.

**Theorem 3.4** If a PFSP  $= (\zeta_P, \eta_P, \gamma_P)$  in  $S$  is a PFBI of  $S$ , then so is  $P^* = (\underline{\zeta}_P, \underline{\eta}_P, \underline{\gamma}_P)$ .

**Proof:** It is sufficient to show that  $\underline{\zeta}_P$  satisfies the conditions in Definition 3.1 and 3.3.

For any  $u, x_1, x_2 \in S$ , we have

$$\begin{aligned} \underline{\zeta}_P(x_1x_2) &= 1 - \zeta_P(x_1x_2) \\ &\leq 1 - \min\{\zeta_P(x_1), \zeta_P(x_2)\} \\ &= \max\{1 - \zeta_P(x_1), 1 - \zeta_P(x_2)\} \\ &= \max\{\underline{\zeta}_P(x_1), \underline{\zeta}_P(x_2)\} \end{aligned}$$

and

$$\begin{aligned} \underline{\zeta}_P(x_1ux_2) &= 1 - \zeta_P(x_1ux_2) \\ &\leq 1 - \min\{\zeta_P(x_1), \zeta_P(x_2)\} \\ &= \max\{1 - \zeta_P(x_1), 1 - \zeta_P(x_2)\} \\ &= \max\{\underline{\zeta}_P(x_1), \underline{\zeta}_P(x_2)\} \end{aligned}$$

Therefore  $P^*$  is a PFBI of  $S$ .

**Definition 3.4:** A Picture fuzzy sub-semigroup  $P = (\zeta_P, \eta_P, \gamma_P)$  of  $S$  is called a Picture fuzzy (1, 2) ideal of  $S$ , if

1.  $\zeta_P(x_1u(x_2x_3)) \geq \min\{\zeta_P(x_1), \zeta_P(x_2), \zeta_P(x_3)\}$
2.  $\eta_P(x_1u(x_2x_3)) \leq \max\{\eta_P(x_1), \eta_P(x_2), \eta_P(x_3)\}$
3.  $\gamma_P(x_1u(x_2x_3)) \leq \max\{\gamma_P(x_1), \gamma_P(x_2), \gamma_P(x_3)\}$

for all  $u, x_1, x_2, x_3 \in S$ .

**Theorem 3.5** Every PFBI is a Picture fuzzy (1,2) ideal of  $S$ .

**Proof:** Let PFS  $P = (\zeta_P, \eta_P, \gamma_P)$  be a PFBI of  $S$  and let  $u, x_1, x_2, x_3 \in S$ .

Then

$$\begin{aligned} \zeta_P(x_1u(x_2x_3)) &= \zeta_P((x_1ux_2)x_3) \\ &\geq \min\{\zeta_P(x_1ux_2), \zeta_P(x_3)\} \\ &\geq \min\{\min\{\zeta_P(x_1), \zeta_P(x_2)\}, \zeta_P(x_3)\} \\ &= \min\{\zeta_P(x_1), \zeta_P(x_2), \zeta_P(x_3)\} \\ \eta_P(x_1u(x_2x_3)) &= \eta_P((x_1ux_2)x_3) \\ &\leq \max\{\eta_P(x_1ux_2), \eta_P(x_3)\} \\ &\leq \max\{\max\{\eta_P(x_1), \zeta_P(x_2)\}, \eta_P(x_3)\} \\ &= \max\{\eta_P(x_1), \eta_P(x_2), \eta_P(x_3)\} \end{aligned}$$

And

$$\gamma_P(x_1u(x_2x_3)) = \gamma_P((x_1ux_2)x_3)$$





Hema and Anitha

$$\begin{aligned} &\leq \max\{\gamma_P(x_1ux_2), \gamma_P(x_3)\} \\ &\leq \max\{\max\{\gamma_P(x_1), \zeta_P(x_2)\}, \gamma_P(x_3)\} \\ &= \max\{\gamma_P(x_1), \gamma_P(x_2), \gamma_P(x_3)\} \end{aligned}$$

Hence  $P = (\zeta_P, \eta_P, \gamma_P)$  is a Picture fuzzy (1,2) ideal of  $S$ .

**Theorem 3.6** If  $S$  is a regular semigroup, then every Picture fuzzy (PF)(1, 2) ideal of  $S$  is PFBI of  $S$ .

**Proof:** Assume that a semigroup  $S$  is regular and let  $P = (\zeta_P, \eta_P, \gamma_P)$  be a Picture fuzzy (1,2) ideal of  $S$ . Let  $u, x_1, x_2, x_3 \in S$ . Since  $S$  is regular, we have  $x_1u \in (x_1sx_1)s \subseteq x_1sx_1$ , then  $x_1u = x_1sx_1$  for some  $s \in S$ .

Thus

$$\begin{aligned} \zeta_P(x_1ux_2) &= \zeta_P((x_1sx_1)x_2) \\ &= \zeta_P(x_1s(x_1x_2)) \\ &\geq \min\{\zeta_P(x_1), \zeta_P(x_1), \zeta_P(x_2)\} \\ &= \min\{\zeta_P(x_1), \zeta_P(x_2)\} \\ \eta_P(x_1ux_2) &= \eta_P((x_1sx_1)x_2) \\ &= \eta_P(x_1s(x_1x_2)) \\ &\leq \max\{\eta_P(x_1), \eta_P(x_1), \eta_P(x_2)\} \\ &= \max\{\eta_P(x_1), \eta_P(x_2)\} \end{aligned}$$

And

$$\begin{aligned} \gamma_P(x_1ux_2) &= \gamma_P((x_1sx_1)x_2) \\ &= \gamma_P(x_1s(x_1x_2)) \leq \max\{\gamma_P(x_1), \gamma_P(x_1), \gamma_P(x_2)\} \\ &= \max\{\gamma_P(x_1), \gamma_P(x_2)\} \end{aligned}$$

Therefore  $P = (\zeta_P, \eta_P, \gamma_P)$  is  $P_i$ FBI of  $S$ .

**Theorem 3.7** A PFSP  $P = (\zeta_P, \eta_P, \gamma_P)$  is a PFBI of  $S$  if and only if the fuzzy sets  $\zeta_P, \eta_P$  and  $\gamma_P$  are FBI of  $S$ .

**Proof:** Let  $P = (\zeta_P, \eta_P, \gamma_P)$  be a PFBI of  $S$ . Then clearly  $\zeta_P$  and  $\eta_P$  are FBI of  $S$ . It is enough to show that  $\gamma_P$  is a FBI of  $S$ . For any  $u, x_1, x_2 \in S$ .

Then

$$\begin{aligned} \gamma_P(x_1x_2) &= 1 - \gamma_P(x_1x_2) \\ &\geq 1 - \max\{\gamma_P(x_1), \gamma_P(x_2)\} \\ &= \min\{1 - \gamma_P(x_1), 1 - \gamma_P(x_2)\} \\ &= \min\{\gamma_P(x_1), \gamma_P(x_2)\} \end{aligned}$$

and

$$\begin{aligned} \gamma_P(x_1ux_2) &= 1 - \gamma_P(x_1ux_2) \\ &\geq 1 - \max\{\gamma_P(x_1), \gamma_P(x_2)\} \\ &= \min\{1 - \gamma_P(x_1), 1 - \gamma_P(x_2)\} \\ &= \min\{\gamma_P(x_1), \gamma_P(x_2)\}. \end{aligned}$$

Hence  $\gamma_P$  is a fuzzy bi-ideal of  $S$ .

Conversely, suppose that  $\zeta_P, \eta_P$  and  $\gamma_P$  are FBI of  $S$ . Let  $u, x_1, x_2 \in S$ .

Then

$$\begin{aligned} 1 - \gamma_P(x_1x_2) &= \gamma_P(x_1x_2) \\ &\geq \min\{\gamma_P(x_1), \gamma_P(x_2)\} \\ &= \min\{1 - \gamma_P(x_1), 1 - \gamma_P(x_2)\} \\ &= \max\{\gamma_P(x_1), \gamma_P(x_2)\} \\ 1 - \gamma_P(x_1ux_2) &= \gamma_P(x_1ux_2) \\ &\geq \min\{\gamma_P(x_1), \gamma_P(x_2)\} \\ &= \min\{1 - \gamma_P(x_1), 1 - \gamma_P(x_2)\} \\ &= 1 - \max\{\gamma_P(x_1), \gamma_P(x_2)\} \end{aligned}$$

Thus  $\gamma_P(x_1x_2) \leq \max\{\gamma_P(x_1), \gamma_P(x_2)\}$  and  $\gamma_P(x_1ux_2) \leq \max\{\gamma_P(x_1), \gamma_P(x_2)\}$ .

Hence the proof.





Hema and Anitha

**Definition 3.5:** A PFSP =  $(\zeta_P, \eta_P, \gamma_P)$  of  $S$  is called a Picture fuzzy interior ideal (PFII) of  $S$ , if it satisfies

1.  $\zeta_P(x_1ux_2) \geq \zeta_P(u)$
2.  $\eta_P(x_1ux_2) \leq \eta_P(u)$
3.  $\gamma_P(x_1ux_2) \leq \gamma_P(u)$  for all  $u, x_1, x_2 \in S$ .

**Example 3.4:** Table- 1 Define a Picture fuzzy set  $P = (\zeta_P, \eta_P, \gamma_P)$  in  $S$  as follows. Thus  $P = (\zeta_P, \eta_P, \gamma_P)$  is Picture fuzzy interior ideal of  $S$ .

**Theorem 3.8** If  $\{P_i\}_{i \in I}$  is a family of PFIntI of  $S$ , then  $\cap P_i$  is a PFII of  $S$ , where  $\cap P_i = (\wedge \zeta_{P_i}, \wedge \eta_{P_i}, \vee \gamma_{P_i})$  and  $\wedge \zeta_{P_i}, \wedge \eta_{P_i}, \vee \gamma_{P_i}$  are defined as follows.

$$\wedge \zeta_{P_i}(x_1) = \inf\{\zeta_{P_i}(x_1) | i \in I, x_1 \in S\},$$

$$\wedge \eta_{P_i}(x_1) = \sup\{\eta_{P_i}(x_1) | i \in I, x_1 \in S\},$$

$$\vee \gamma_{P_i}(x_1) = \sup\{\gamma_{P_i}(x_1) | i \in I, x_1 \in S\}.$$

*Proof.* Let  $u, x_1, x_2 \in S$ . Then, we have

$$\wedge \zeta_{P_i}(x_1x_2) \geq \inf\{\min\{\zeta_{P_i}(x_1), \zeta_{P_i}(x_2)\}\}$$

$$= \min\{\inf(\zeta_{P_i}(x_1)), \inf(\zeta_{P_i}(x_2))\}$$

$$\wedge \eta_{P_i}(x_1x_2) \leq \sup\{\max\{\eta_{P_i}(x_1), \eta_{P_i}(x_2)\}\}$$

$$= \max\{\inf(\eta_{P_i}(x_1)), \sup(\eta_{P_i}(x_2))\}$$

and

$$\vee \gamma_{P_i}(x_1x_2) \leq \sup\{\max\{\gamma_{P_i}(x_1), \gamma_{P_i}(x_2)\}\}$$

$$= \max\{\sup(\gamma_{P_i}(x_1)), \sup(\gamma_{P_i}(x_2))\}$$

$$\wedge \zeta_{P_i}(x_1ux_2) \geq \inf \zeta_{P_i}(u)$$

$$\wedge \eta_{P_i}(x_1ux_2) \leq \sup \eta_{P_i}(u)$$

and

$$\vee \gamma_{P_i}(x_1ux_2) \leq \sup \gamma_{P_i}(u).$$

Hence  $\cap P_i$  is a PFII of  $S$ .

**Theorem 3.9** A PFSP =  $(\zeta_P, \eta_P, \gamma_P)$  is a PFII of  $S$  if and only if the fuzzy sets  $\zeta_P, \eta_P$  and  $\gamma_P$  are FII of  $S$ .

**Proof:** Let  $P = (\zeta_P, \eta_P, \gamma_P)$  be a PFII of  $S$ . Then clearly  $\zeta_P$  is a FII of  $S$ . Let  $u, x_1, x_2 \in S$ .

Then

$$\gamma_P(x_1x_2) = 1 - \gamma_P(x_1x_2)$$

$$\geq 1 - (\gamma_P(x_1) \vee \gamma_P(x_2))$$

$$= 1 - \max\{\gamma_P(x_1), \gamma_P(x_2)\}$$

$$= (1 - \gamma_P(x_1)) \wedge (1 - \gamma_P(x_2))$$

$$= \min\{\gamma_P(x_1), \gamma_P(x_2)\}$$

And

$$\gamma_P(x_1ux_2) = 1 - \gamma_P(x_1ux_2)$$

$$\geq 1 - \gamma_P(u)$$

$$= \gamma_P(u).$$

$\gamma_P$  is a FII of  $S$ .

Conversely, suppose that  $\zeta_P, \eta_P$  and  $\gamma_P$  are FII of  $S$ . Let  $u, x_1, x_2 \in S$ .

Then

$$1 - \gamma_P(x_1x_2) = \gamma_P(x_1x_2)$$

$$\geq \gamma_P(x_1) \wedge \gamma_P(x_2)$$

$$= (1 - \gamma_P(x_1)) \wedge (1 - \gamma_P(x_2))$$

$$= 1 - \max\{\gamma_P(x_1), \gamma_P(x_2)\}$$

Then

$$\gamma_P(x_1x_2) \leq \gamma_P(x_1) \vee \gamma_P(x_2)$$







$$\begin{aligned} \text{Next } 1 - \gamma_p(x_1ux_2) &= \gamma_p(x_1ux_2) \\ &\geq \gamma_p(u) \\ &= 1 - \gamma_p(u) \end{aligned}$$

Which implies  $\gamma_p(x_1ux_2) \leq \gamma_p(u)$ .

This completes the proof.

**Homomorphism of picture fuzzy ideals in semi groups**

In this subsection a homo morphism principle can be applied in a picture fuzzy bi-ideal and picture fuzzy interior ideal. Let  $g$  be a mapping from a set  $A$  to a set  $B$ . If  $p_1 = (\zeta_{p_1}, \eta_{p_1}, \gamma_{p_1})$  and  $p_2 = (\zeta_{p_2}, \eta_{p_2}, \gamma_{p_2})$  are picture fuzzy set in  $A$  and  $B$  respectively then the preimage of  $B$  under  $g$ , denoted by  $g^{-1}(p_2)$  is a PFS in  $p_1$  defined by  $g^{-1}(p_2) = (g^{-1}(\zeta_{p_2}), g^{-1}(\eta_{p_2}), g^{-1}(\gamma_{p_2}))$

**Theorem 4.1**

Let  $g: S \rightarrow T$  be homomorphism of semigroups. If  $p_2 = (\zeta_{p_2}, \eta_{p_2}, \gamma_{p_2})$  is picture fuzzy bi-ideal (PFBI) of  $T$ . Then the preimage  $g^{-1}(p_2) = (g^{-1}(\zeta_{p_2}), g^{-1}(\eta_{p_2}), g^{-1}(\gamma_{p_2}))$  of  $p_2$  under  $g$  is PFBI of  $S$ .

**Proof** Assume that  $p_2 = (\zeta_{p_2}, \eta_{p_2}, \gamma_{p_2})$  is a PFBI of  $T$  and let  $x_1, x_2 \in S$ , then

$$\begin{aligned} (g^{-1} \zeta_{p_2})(x_1x_2) &= \zeta_{p_2}(g(x_1x_2)) \\ &= \zeta_{p_2}(g(x_1), g(x_2)) \\ &\geq \min \{ \zeta_{p_2}(g(x_1)), \zeta_{p_2}(g(x_2)) \} \\ &= \min \{ (g^{-1}(\zeta_{p_2}(x_1))), (g^{-1}(\zeta_{p_2}(x_2))) \} \\ (g^{-1} \eta_{p_2})(x_1x_2) &= \eta_{p_2}(g(x_1x_2)) \\ &= \eta_{p_2}(g(x_1), g(x_2)) \\ &\leq \max \{ \eta_{p_2}(g(x_1)), \eta_{p_2}(g(x_2)) \} \\ &= \max \{ (g^{-1}(\eta_{p_2}(x_1))), (g^{-1}(\eta_{p_2}(x_2))) \} \\ \text{and } (g^{-1} \gamma_{p_2})(x_1x_2) &= \gamma_{p_2}(g(x_1x_2)) \\ &= \gamma_{p_2}(g(x_1), g(x_2)) \\ &\leq \max \{ \gamma_{p_2}(g(x_1)), \gamma_{p_2}(g(x_2)) \} \\ &= \max \{ (g^{-1}(\gamma_{p_2}(x_1))), (g^{-1}(\gamma_{p_2}(x_2))) \} \end{aligned}$$

Hence  $g^{-1}(p_2) = (g^{-1}(\zeta_{p_2}), g^{-1}(\eta_{p_2}), g^{-1}(\gamma_{p_2}))$  is a picture fuzzy sub-semigroup of  $S$ .

For any  $u, x_1, x_2 \in S$ ,

$$\begin{aligned} (g^{-1} \zeta_{p_2})(x_1ux_2) &= \zeta_{p_2}(g(x_1ux_2)) \\ &= \zeta_{p_2}(g(x_1), g(u), g(x_2)) \\ &\geq \min \{ \zeta_{p_2}(g(x_1)), \zeta_{p_2}(g(x_2)) \} \\ &= \min \{ (g^{-1}(\zeta_{p_2}(x_1))), (g^{-1}(\zeta_{p_2}(x_2))) \} \\ (g^{-1} \eta_{p_2})(x_1ux_2) &= \eta_{p_2}(g(x_1ux_2)) \\ &= \eta_{p_2}(g(x_1), g(u), g(x_2)) \\ &\leq \max \{ \eta_{p_2}(g(x_1)), \eta_{p_2}(g(x_2)) \} \\ &= \max \{ (g^{-1}(\eta_{p_2}(x_1))), (g^{-1}(\eta_{p_2}(x_2))) \} \\ \text{and } (g^{-1} \gamma_{p_2})(x_1ux_2) &= \gamma_{p_2}(g(x_1ux_2)) \\ &= \gamma_{p_2}(g(x_1), g(u), g(x_2)) \\ &\leq \max \{ \gamma_{p_2}(g(x_1)), \gamma_{p_2}(g(x_2)) \} \\ &= \max \{ (g^{-1}(\gamma_{p_2}(x_1))), (g^{-1}(\gamma_{p_2}(x_2))) \} \end{aligned}$$

Therefore  $g^{-1}(p_2) = (g^{-1}(\zeta_{p_2}), g^{-1}(\eta_{p_2}), g^{-1}(\gamma_{p_2}))$  is a PFBI of  $S$ .

**Theorem 4.2**

Let  $g: S \rightarrow T$  be homomorphism of semigroups. If  $p_2 = (\zeta_{p_2}, \eta_{p_2}, \gamma_{p_2})$  is picture fuzzy interior ideal (PFII) of  $T$ , then the preimage  $g^{-1}(p_2) = (g^{-1}(\zeta_{p_2}), g^{-1}(\eta_{p_2}), g^{-1}(\gamma_{p_2}))$  of  $p_2$  under  $g$  is PFII of  $S$ .





**Hema and Anitha**

**Proof**

Assume that  $p_2 = (\zeta_{p_2}, \eta_{p_2}, \gamma_{p_2})$  is picture fuzzy interior ideal (PFII) of  $S$  and let  $x_1, x_2 \in S$ , then

$$\begin{aligned}
 (g^{-1} \zeta_{p_2})(x_1 x_2) &= \zeta_{p_2}(g(x_1 x_2)) \\
 &= \zeta_{p_2}(g(x_1), g(x_2)) \\
 &\geq \zeta_{p_2}(g(x_1)) \wedge \zeta_{p_2}(g(x_2)) \\
 = g^{-1}(\zeta_{p_2}(x_1)) \wedge g^{-1}(\zeta_{p_2}(x_2)) \\
 (g^{-1} \eta_{p_2})(x_1 x_2) &= \eta_{p_2}(g(x_1 x_2)) \\
 &= \eta_{p_2}(g(x_1), g(x_2)) \\
 &\leq \eta_{p_2}(g(x_1)) \vee \eta_{p_2}(g(x_2)) \\
 &= g^{-1}((\eta_{p_2}(x_1)) \vee \eta_{p_2}(x_2)) \\
 \text{and } (g^{-1} \gamma_{p_2})(x_1 x_2) &= \gamma_{p_2}(g(x_1 x_2)) \\
 &= \gamma_{p_2}(g(x_1), g(x_2)) \\
 &\leq \gamma_{p_2}(g(x_1)) \vee \gamma_{p_2}(g(x_2)) \\
 &= g^{-1}(\gamma_{p_2}(x_1) \vee \gamma_{p_2}(x_2))
 \end{aligned}$$

Hence  $g^{-1}(p_2) = (g^{-1}(\zeta_{p_2}), g^{-1}(\eta_{p_2}), g^{-1}(\gamma_{p_2}))$  is a picture fuzzy sub-semigroup of  $S$ .

For any  $u, x_1, x_2 \in S$ , we have

$$\begin{aligned}
 (g^{-1} \zeta_{p_2})(x_1 u x_2) &= \zeta_{p_2}(g(x_1 u x_2)) \\
 &= \zeta_{p_2}(g(x_1), g(u), g(x_2)) \\
 &\geq \zeta_{p_2}(g(u)) \\
 &= g^{-1}(\zeta_{p_2}(u)) \\
 (g^{-1} \eta_{p_2})(x_1 u x_2) &= \eta_{p_2}(g(x_1 u x_2)) \\
 &= \eta_{p_2}(g(x_1), g(u), g(x_2)) \\
 &\leq \eta_{p_2}(g(u)) \\
 &= g^{-1}(\eta_{p_2}(u)) \\
 \text{and } (g^{-1} \gamma_{p_2})(x_1 u x_2) &= \gamma_{p_2}(g(x_1 u x_2)) \\
 &= \gamma_{p_2}(g(x_1), g(u), g(x_2)) \\
 &\leq \gamma_{p_2}(g(u)) \\
 &= g^{-1}(\gamma_{p_2}(u))
 \end{aligned}$$

Therefore  $g^{-1}(p_2) = (g^{-1}(\zeta_{p_2}), g^{-1}(\eta_{p_2}), g^{-1}(\gamma_{p_2}))$  is a PFII of  $S$ .

**CONCLUSION**

Picture fuzzy ideals (PFI) of  $S$  will provide with the distinct study of the attributes and alternatives and they are usually needed in the current scenario like Twitter, what's app and so on. This paper contributes to the study of picture fuzzy algebraic structures by way of discussing the PFI of semi groups. Some of the definitions of PFI of  $S$ , such as PF sub- semi group, PF left (resp. right), PFBI, PF (1,2) ideal, PFI have been defined. Except PF (1,2) ideal, remaining definitions were used to solve the illustrative examples. Afterwards theorems of PFI of semi group have been proved. Later on, every PFBI of  $S$  is a PF (1,2) ideal of  $S$ . In addition to that we add a one condition of regular every PF (1,2) ideal of  $S$  is a PFBI of especially  $P$  is a PFII of  $S$  if and only if fuzzy set  $\zeta_p, \eta_p$  and  $\gamma_p$  are FII of  $S$ . Finally, homomorphism of PFI of semigroup were proved based on the principles has been performed with PFBI and PFII. Several interesting properties of PFI of semi groups and theorems were investigated and some examples are shown through a picture fuzzy environment. Therefore, the results in this study may be considered for generalizations of PFI of semi groups and it will be noteworthy to study picture fuzzy quasi-ideals of semi groups, Rough PFIS and Soft PFIS in future studies; and it could also elaborate more results on PFI for a finite number of semi groups. Some of the definitions of PFI of  $S$  were discussed and used to solve the illustrative examples. We reached the proof of the theorems in picture fuzzy concepts of several ideals in semi groups  $S$ , and investigated some properties. This study





**Hema and Anitha**

may be developed for PFI in gamma semi groups in our future work. PFI in ordered semi groups; Interval valued PFI in semi groups and so on.

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**Table 1: Cayley table**

•	<i>a</i>	<i>b</i>	<i>c</i>	<i>d</i>
<i>a</i>	a	a	a	a
<i>b</i>	a	a	a	a





**Hema and Anitha**

<i>c</i>	a	a	b	a
<i>d</i>	a	a	b	b

**Table 2: Picture fuzzy sub-semigroup**

<i>S</i>	$\zeta(x)$	$\eta(x)$	$\gamma(x)$
<i>a</i>	0.3	0.2	0.2
<i>b</i>	0.2	0.4	0.2
<i>c</i>	0.1	0.4	0.4
<i>d</i>	0.2	0.4	0.3

**Table 3: Picture fuzzy bi-ideal**

<i>S</i>	$\zeta(x)$	$\eta(x)$	$\gamma(x)$
<i>a</i>	0.4	0.3	0.3
<i>b</i>	0.3	0.2	0.4
<i>c</i>	0.2	0.1	0.5
<i>d</i>	0.1	0.2	0.5

**Table 4: Picture fuzzy interior ideal**

<i>S</i>	$\zeta(x)$	$\eta(x)$	$\gamma(x)$
<i>a</i>	0.3	0.1	0.2
<i>b</i>	0.2	0.2	0.4
<i>c</i>	0.1	0.3	0.5
<i>d</i>	0.2	0.3	0.4





## ***In-vitro* Antioxidants assessment and herbal capsule formulation of aerial parts of *Enhydra fluctuans***

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### **ABSTRACT**

*Enhydra fluctuans*, commonly known as water lettuce, is a versatile aquatic plant known for its traditional medicinal uses. This study aimed to evaluate the antioxidant potential of the aerial parts of *Enhydra fluctuans* through in-vitro and in-vivo experiments, and subsequently develop a herbal capsule formulation for potential therapeutic applications. For the in-vitro assessment, various antioxidant assays were conducted, including DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assays. The results revealed significant antioxidant activity in *Enhydra fluctuans*, suggesting its potential as a natural source of antioxidants. The formulation was characterized for its phytochemical profile, other parameters. This research provides valuable insights into the antioxidant potential of *Enhydra fluctuans*, supporting its traditional use in herbal medicine. The herbal capsule formulation offers a convenient and standardized way to harness these antioxidant properties for potential therapeutic applications. Further clinical studies are warranted to explore the full range of health benefits and safety profile of this herbal remedy.

**Keywords:** *Enhydra fluctuans*, Phytoconstituents, Antioxidant, Formulation.



**Mrinmoy Basak et al.,**

## INTRODUCTION

Oxidative stress, characterized by an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defense mechanisms, is implicated in the pathogenesis of various chronic diseases, including cardiovascular disorders, neurodegenerative conditions, and cancer [1][2][3]. To combat oxidative stress and its associated health risks, there is a growing interest in the exploration of natural antioxidants derived from botanical sources. *Enhydra fluctuans*, commonly known as water lettuce, is one such plant that has garnered attention for its potential as a source of natural antioxidants. *Enhydra fluctuans* is a resilient aquatic plant indigenous to various regions, including Southeast Asia, and has been employed traditionally for its medicinal properties [4]. The aerial parts of this plant have been reported to contain a diverse array of bioactive compounds, including phenolic compounds, flavonoids, and terpenoids, which are known for their antioxidant properties [5]. The utilization of *Enhydra fluctuans* as a natural antioxidant source presents a promising avenue for addressing oxidative stress-related health issues. This study endeavors to comprehensively assess the antioxidant potential of the aerial parts of *Enhydra fluctuans* through both in-vitro and in-vivo methodologies. In-vitro assays provide valuable insights into the radical-scavenging and reducing capabilities of the plant extract, shedding light on its potential efficacy as an antioxidant agent [6]. Additionally, in-vivo experiments involving animal models allow for the evaluation of the plant's antioxidant effects within a biological system, providing a more holistic understanding of its therapeutic potential [7]. Furthermore, this research aims to extend the scope of *Enhydra fluctuans* by developing a herbal capsule formulation, which not only ensures the standardized delivery of its antioxidant components but also enhances its practicality and convenience as a therapeutic agent.

The formulation process involves the extraction and standardization of bioactive compounds from *Enhydra fluctuans*, followed by their incorporation into pharmaceutical-grade capsules. This approach aligns with the contemporary trend in herbal medicine, where natural remedies are transformed into user-friendly and dosage-controlled forms for enhanced patient compliance and reproducibility [8]. The potential of *Enhydra fluctuans* to serve as a natural antioxidant source, supported by rigorous in-vitro and in-vivo assessments and facilitated by a standardized herbal capsule formulation, may offer a novel strategy in the quest for effective antioxidant-based therapeutics. Furthermore, this research holds promise in revitalizing the traditional knowledge associated with *Enhydra fluctuans*, consolidating its place in contemporary herbal medicine. In this paper, we present the results of our in-vitro and in-vivo antioxidant assessments of *Enhydra fluctuans* and discuss the development and characterization of a herbal capsule formulation for potential therapeutic applications.

## METHODOLOGY

### Collection and authentication of plant materials

The fresh aerial parts of *Enhydra fluctuans* were collected from the locality of Bonda Amgaon of Kamrup (rural) district, Assam, India. The herbarium was prepared and authentication of plant species was done in Gauhati University, Assam, India.

### Extraction

The extraction was done by the process of cold maceration using 100 grams of shed dried powder of plant extract with ethanol as a solvent. The obtained preparation was filtered and the filtrates are concentrated to sticky mass using Rota evaporator 3.42% was calculated as extractive value [9].

### Pharmacognostic study

The morphology and microscopic observation was done. The preliminary test Phyto chemical constituents such as test for alkaloids, glycosides, flavonoids, steroids, phenanthrene, phenolic compound and tannins were done [10].

### Acute Toxicity Study

As per the OECD guidelines the oral acute toxicity study was carried out on the experimental rats. **DPPH radical**







**Mrinmoy Basak et al.,**

### scavenging potency

The DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity assay is a commonly used method to assess the antioxidant capacity of natural compounds or extracts. It measures the ability of a sample to donate an electron or hydrogen atom to the stable DPPH free radical, resulting in a color change from purple to yellow. A 0.1 m mol solution of DPPH was prepared with ethanol from this 1ml solution was mixed with 0.3 ml of ethanolic extract, different fractions of *Enhydra fluctuans* at different concentrations (5, 10, 20, 30, 40 & 80 mcg/ml), the prepared solution was kept aside at room temperature for 30 minutes. The test samples were studied in UV visible spectrophotometer at 517 nm and the absorbance was recorded. Each sample was tested against an appropriate blank also keeping one positive control in parallel set up without sample extract. Ascorbic acid as a standard was tested at different concentrations. Calculate the percentage of DPPH radical scavenging activity using the formula:

Scavenging activity (%) =  $[(\text{Abs\_control} - \text{Abs\_sample}) / \text{Abs\_control}] \times 100$ , where Abs\_control is the absorbance of the control and Abs\_sample is the absorbance of the sample [102].

### Herbal capsule formulation

The capsule formulation was designed using the dried fractions of two different plants species in corporation with other compatible excipients. Pre-formulation study: The study was done with the ethyl acetate fractions of both the plants extracts, the selection of excipients added and also the blended powder drugs. All experimental batches of blended powder had their flow parameters, such as bulk density, tap density, compressibility index, and angle of repose, examined. Carr's index, tap density, and bulk density [115]. In a 50 ml measuring cylinder, 15g of powdered substance that had been weighed was added. Additionally, after recording the initial volume (v<sub>0</sub>), the contents were tapped 50 times, and the powdered volumes were recorded (v<sub>50</sub>). The following is the formula for fluff density and tapped density.

Density of fluff =  $w/v_0$  g/cc

Tapped density =  $50$  g/cc  $w/v_0$ .

Powder drug physical parameters:

Carr's index =  $\{ \text{Tapped density} - \text{Fluff density} / \text{Tapped density} \} \times 100$  Value for Carr's index below 15 indicate excellent flowing material and value over 20-30 suggested poor flowing material.

### Angle of repose

A funnel was fixed at a particular height (1.5, 2.5, 3.5 cm) on a burette stand. A white paper was placed below the funnel on the table. The powdered drug passed slowly through the funnel until it forms a pile. The radius of the pile was noted down. Angle of repose of the powder material was calculated by using the formula  $\tan \theta = h/r$ ,  $\theta = \tan^{-1}(h/r)$  where, h = height of the pile, r = radius. Values for angle of repose < 30° usually indicate a free flowing material and angle > 56° suggest a poor flowing material.

### Preservatives

To stop bacterial, fungal, and other microbes from contaminating, degrading, and spoiling herbal formulations, preservatives are added. The sodium methyl paraben, sodium propyl paraben, sodium benzoate, and bronopol are the preservatives that work the best. Below is a list of the excipients used in the formulation.

1. Talc - Glidant/Lubricant
2. Microcrystalline cellulose - Diluent/Disintegrant
3. Starch - Binder/Disintegrant
4. Magnesium stearate - Lubricant
5. Sodium methyl Paraben – Preservative

**Formulation preparation** in a tray dryer set at 60 °C was used to dry the dry CTEAF (Combination of Two ethyl acetate fractions) for 20 minutes. With the exception of preservatives, all excipients used in this formulation were dried separately in a tray dryer at 100°C for 30 minutes. Magnesium stearate was used to lubricate and blend all of the active components in accordance with the formula, then diluents and preservatives were properly combined. For 30 minutes, the material was well mixed. After that, the powder was put into polythene bags and marked for later research [115].



**Mrinmoy Basak et al.,****Standardization of herbal capsules****Test for Weight Variation in Herbal Capsules**

The weight variation test was used to determine how variable the amount of powder in each herbal capsule was. We chose twenty herbal capsules at random and weighed them. The average weight was then determined and compared to the weight of each herbal capsule. According to USP (2010) Specification, the % weight variation was computed. The weight of the herbal capsule must be between 90% and 110% of the weight of each unit as estimated theoretically [116].

**Procedure**

20 units were randomly chosen, their contents weighed, and an average weight calculation was made. The average weight isn't deviated from by more than two individual weights combined that is, capsule <300 mg the maximum weight deviation can be 10% and capsule with average weight >300mg can have a maximum deviation of 7.5%.

**Moisture contents**

A herb or herbal powders is known to be hygroscopic, the loss on drying test is crucial. The presence of fungi, insects, and microbial growth are all encouraged by an excess of water in medicinal plant components. The water content gives information about the medications' quality and shelf life in modern pharmaceutical technology [115]. Final weight of the sample divided by initial weight of the sample yields moisture content (%) of 100. Testing for herbal capsules' disintegration: The disintegration test is quite helpful for ensuring the quality of conventional dosage forms. Utilising disintegration test equipment, the test is run. A medication's or dose form's effectiveness is solely reliant on how quickly the formulation breaks down in the patient's digestive system. For the disintegration test, six herbal capsules were chosen at random. Throughout the experiment, the disintegration apparatus was kept at a temperature of 37°C + 2°C. The capsule was put in each tube before being suspended for 30 minutes in beakers containing simulated gastric fluid (SGF, pH 1.2). The disintegration test is a measurement of the amount of time needed under a certain set of circumstances for selected capsules to fragment into particles that pass through a 10 mesh screen in a predetermined amount of time [117]. The outcomes were summarised in Table 3. *In-vitro* dissolution studies for herbal capsules: To create the stock solution, which has a concentration of 1000 g/mL, 100 mg of the powder drugs from the formulated capsules were dissolved in a small amount of distilled water and built up to 100 mL with distilled water.

**Determination of Absorption maxima**

Using a UV spectrophotometer, the sample was run from 200 to 400 nm to determine the stock solution's absorption maximum. Preparation of Calibration Curve using distilled water, the stock solution was successively diluted to achieve concentrations of 50, 100, 200, 300, 400, and 500 g/mL. Using a UV spectrophotometer, the absorbance was measured for each quantity against distilled water as a blank at 304 nm (Table 2). Plotting the graph using the absorbance readings against the concentration (g/mL), the standard calibration curve was created [118].

**In vitro dissolution test**

Dissolution is thought of as a technique for forecasting how quickly medications given orally would be absorbed and how bio available they will be. The jar was filled with the Paddle type dissolution device, which contained 900 ml of simulated gastric fluid (SGF, pH 1.2), and the temperature was kept at 37°C–2°C. For 30 minutes, the paddle was left to spin at 50 rpm. At predefined times (0, 5, 10, 15, 20, 25, 30, 35, and 40), 5 mL of the dissolution media were removed and fresh dissolution medium was substituted. The removed samples were examined using a UV Spectrophotometer at 304 nm. In Table 4, the cumulative drug release (CDR) was tallied and calculated [119].

**FT-IR analysis**

A spectrum of the infrared wave was captured by scanning the sample on discs of potassium bromide. To validate the functional group's presence, the vibrational spectra of formulation and separately on each ethyl acetate fractions of the both plants species [120].





Mrinmoy Basak et al.,

## RESULT AND DISCUSSION

### Morphological parameters

**Microscopic evaluation** The freshly collected aerial part transverse section was made and dried powder of the same was observed under microscope at 40x magnification shown in **figure 1**, and **2** respectively.

**Phyto chemical Screening** The ethanol extract was processed for the Detection of alkaloids, glycosides, flavonoids, phenols, carbohydrate and saponin was obtained results shown in **Table 2**.

### Herbal Capsule formulation

A dried ethanol extract of *Enhydra fluctuans* were is included in the formulation of a herbal capsule. The pharmacologically potent dried powder drugs were used to create the herbal capsule, together with additives such as talc as glidant/lubricant, micro crystalline cellulose and starch as diluent/disintegrants, magnesium stearate as a lubricant and sodium methyl paraben used as a preservative in the poly herbal formulated capsule.

### Pre-formulation evaluation

Pre-formulation factors such bulk density, tap density, Carr's index, and angle of repose were examined on three trial batches of the herbal formulation. Table 8 depicts the results that were seen. The formulated powder drugs were evaluated with a poor flow property as represented with a slight deviation of angle of repose and Carr's index of 44.8° and 28.2% (w/w) respectively.

### Organoleptic parameters

The powders are in pale brown colour which encapsulated in red cap and purple body "1" size capsule shell of hard gelatine. The odour was characteristics with a taste of bitterness.

### Preparation of Calibration curve

The absorbance data were plotted against the concentration (g/mL) to create the standard calibration curve. The model was determined to have a satisfactory fit to the empirical data and to have appropriate efficacy based on the R<sup>2</sup> value of 0.9121 (Fig. 1).

### Evaluation of herbal capsules

The most crucial component for every formulation to ensure quality, safety, and reproducibility is standardisation [5]. The quality control criteria for the manufactured herbal capsules, such as weight fluctuation, disintegration, and in-vitro dissolution investigations, were assessed. Test for Weight Variation: If the average weight of the capsule is less than 300 mg, the percentage deviation is 10% in accordance with USP Specification [6]. The prepared herbal capsules have a maximum percentage variance of 2.68 %.

### Test for Disintegration

The herbal tablet passed the test because there was no medication leftover. If every capsule has entirely destroyed, the capsule passes the test as determined by USP [11]. The herbal product's breakdown time was noted as 9.32 0.31 minutes for capsules (Table 4).

### Test for In vitro Dissolution

As shown in the Table 4 and Fig 2, 93.17% of the drug was released in 40 minutes, which is an appropriate amount of time for standard dose forms.

### FT-IR study

The ethanol extract of the plant species and formulated capsules powders were studied using FTIR. The FTIR spectra of the ethyl acetate fraction of plants as well as formulation are depicted in Fig. 2, respectively. The frequency areas or bands in each sample reflect the specific functional groupings of compounds. The results from the various spectra indicate that the plants fractions and formulated product contain tannins, alkaloids, steroids, polyphenols, and flavonoids. The smallest wavenumber shift in the herbal formulation indicates the excipients' inert behaviour [17].

## ACKNOWLEDGEMENT

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## CONCLUSION

In conclusion, this study has provided valuable insights into the antioxidant potential of the aerial parts of *Enhydra fluctuans*, a versatile aquatic plant with traditional medicinal uses. Through a comprehensive in-vitro antioxidant



**Mrinmoy Basak et al.,**

assessment, we observed significant radical-scavenging and reducing capabilities in the plant extract, highlighting its promise as a natural source of antioxidants. These findings are consistent with the rich phyto chemical profile reported in previous studies, including phenolic compounds, flavonoids, and terpenoids, which are known for their antioxidant properties. The development of a standardized herbal capsule formulation further enhances the practicality and convenience of harnessing the antioxidant properties of *Enhydra fluctuans*. This formulation ensures consistent delivery of bioactive compounds, facilitating dosage control and patient compliance. It aligns with the modern trend in herbal medicine, where traditional remedies are transformed into pharmaceutical-grade products suitable for contemporary healthcare practices. The combination of in-vitro and in-vivo assessments, along with the development of a herbal capsule formulation, positions *Enhydra fluctuans* as a promising candidate for further exploration in the realm of natural antioxidants and herbal therapeutics. However, it is essential to note that additional research is warranted to ascertain the safety profile, optimal dosage, and full spectrum of health benefits associated with *Enhydra fluctuans* consumption in humans. This research opens avenues for further investigations into the clinical applications of *Enhydra fluctuans* and its potential role in addressing oxidative stress-related health challenges.

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Mrinmoy Basak et al.,

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**Table.1: Morphological characters of leaf (*Enhydra flactuans*)**

Particulars	Observation
Colour	Green
Odour	No
Taste	No
Length	3.0-5.0cm.
Margin	Serrate/Crenate
Apex	Acute
Shape	Linear-oblong
Petioles	Absent
Surface	Glabrous-pubescent.

**Table 2: Phyto chemical screening of ethanol extract of *Enhydra flactuans*(Aerial parts)**

Sl. No.	Constituents	Test	Methanolic Extract
1	Alkaloids	Mayer's reagent	++
		Dragendroff's reagent	++
		Hager's reagent	++
		Wagner's reagent	++
2	Flavonoids	Aqueous NaOH	++
3	Glycosides	Borntrager's reagent	++
		Legal test	++
		Keller kiliani test	++
4	Phenols	Ferric chloride test	++
		Lead acetate test	++
5	Carbohydrate	Molisch's reagent	++
		Fehling's reagent	++
		Benedict reagent	++
		Seliwanoff's reagent	--
6	Saponin	Foam test	++

++ (Positive tests), -- (Negative tests)

**Table 3: Free radical scavenging activity (DPPH) of Ethanol extract of *Enhydra flactuans***

Test items	Concentration (µg/ml)	Absorbance	% Inhibition	IC <sub>50</sub> (µg/ml)
Ascorbic acid	5	0.335±012	35.82484076	23.29
	10	0.298±010	40.53821656	
	20	0.25±016	46.65286624	
	30	0.142±011	60.41082803	
	40	0.107±006	64.86942675	
	80	0.015±002	76.58917197	





Mrinmoy Basak et al.,

Ethanol extract of <i>Enhydra fluctuans</i>	5	0.398±004	27.79936306	35.93
	10	0.353±012	33.53184713	
	20	0.295±010	40.92038217	
	30	0.221±016	50.34713376	
	40	0.145±014	60.02866242	
	80	0.065±009	70.21974522	

Note: Data are expressed as Mean ± Standard deviation (n=3).

**Table 4: Evaluation of in process parameters**

Sl. No.	Parameters	Value (SEM)
1	Bulk density (g/cm)	0.37±0.16
2	Tap density (g/cm)	0.52±0.06
3	Carr's index (%w/w)	25.2±0.04
4	Angle of repose	43.8±0.04

**Table 5: Contains the composition of herbal capsules (250 mg/capsule).**

Sl. No.	Ingredients	Quantity (mg)
1	Ethanol extract of <i>Enhydra fluctuans</i>	200
2	Micro crystalline Cellulose	12.5
3	Sodium methyl paraben	0.25
4	Magnesium stearate	0.85
5	Talc	30
6	Starch	6.4

**Table6: Absorbance of various concentrations of formulated capsule powder.**

Sl. No.	Concentration (µg/mL)	Absorbance
1	50	0.157
2	100	0.168
3	150	0.184
4	200	0.187
5	250	0.214
6	300	0.219

**Table7: Disintegration test of the herbal Capsules of**

Capsule	1	2	3	4	5	6	Mean±SD
Time (Minutes)	9.5	8.6	8.7	9.8	9.2	8.9	9.113±24

**Table8: *In vitro* Dissolution study of the herbal capsules**

Time (Mins)	Cumulative drug release	% Cumulative drug release
0	0	0
5	32.06	8.46
10	62.22	14.06







Mrinmoy Basak et al.,

15	124.02	28.20
20	186.04	46.14
25	275.26	61.04
30	351.14	86.53
35	354.22	88.26
40	366.04	92.02

Table 9: Obtained Vibration (cm<sup>-1</sup>) in formulated capsule powders.

Groups	Vibrations Range (cm <sup>-1</sup> )	Obtained Vibration (cm <sup>-1</sup> )
C-H (alkane)	2850-2975	2822
C=C (alkene)	1640-1680	1653
C=C-H (alkene)	3020-3100	3091
N-H (amines)	3300-3350	3306
aromatics	1650-2000	1687, 1710, 1735, 1878, 1943
C=O (carbonyls)	1700-1760	1710, 1735
CHO (Aldehyde)	1720-1740	1735
RCOOR (Ester)	1735-1750	1735
RCOOH (Acid)	1700-1725	1710
C-O	1250-1050	1081, 1104, 1165, 1187, 1238
C-N	1230-1020	1081, 1104, 1165, 1187
Benzene	~1600 & ~1500-1430	1455

Table 10: Obtained Vibration (cm<sup>-1</sup>) in ethanol extract of *Enhydra fluctuans*

Groups	Vibrations Range (cm <sup>-1</sup> )	Obtained Vibration (cm <sup>-1</sup> )
C-H (alkane)	2850-2975	2852, 2923, 2952
C=C (alkene)	1640-1680	1656
O-H (Alcohol)	3400-3700	3400
C=C (alkyne)	2100-2250	2241
C≡N (Nitrile)	2200-2250	2241
aromatics	1650-2000	1656, 1709, 1833
C=O (carbonyls)	1700-1760	1709
RCOOH (Acid)	1700-1725	1709
C-O	1250-1050	1079, 1163, 1231
C-N	1230-1020	1033, 1079, 1163
Benzene	~1600 & ~1500-1430	1460, 1498,

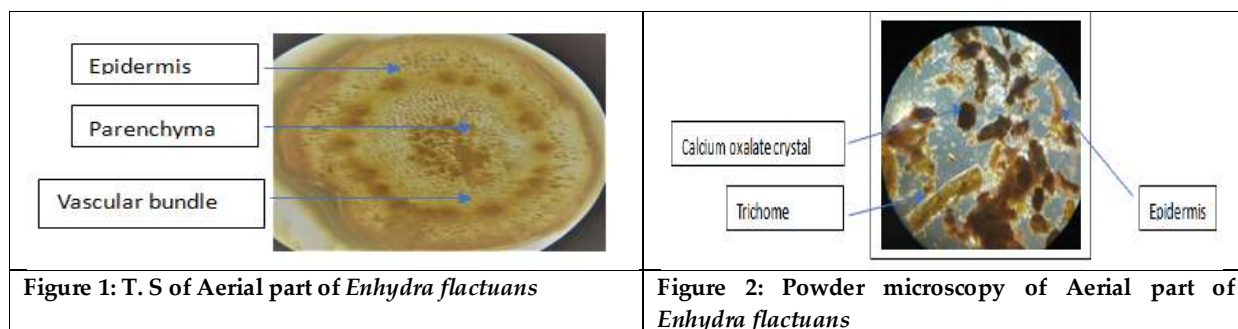
Figure 1: T. S of Aerial part of *Enhydra fluctuans*Figure 2: Powder microscopy of Aerial part of *Enhydra fluctuans*



Figure 3: Steps involved in extraction and phytochemical tests



Figure 4: Formulated capsule of 250 mg weight

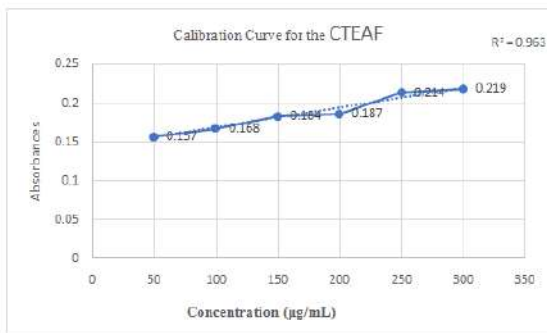


Figure 5: Calibration Curve for the herbal capsules

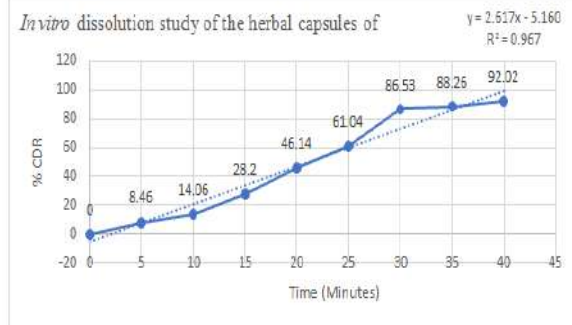


Figure 6: In vitro dissolution study of the herbal capsules

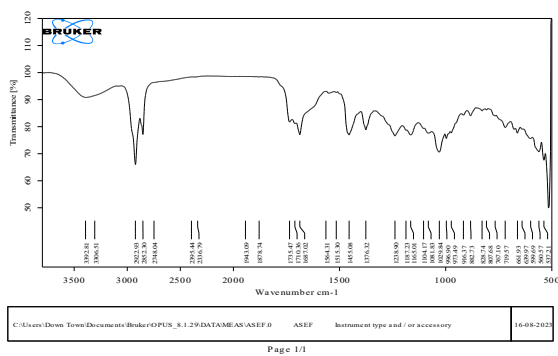


Figure 7: FTIR profiling of different plants fractions and formulation A: Represent the ethanol extract of *Enhydra flactuans*,

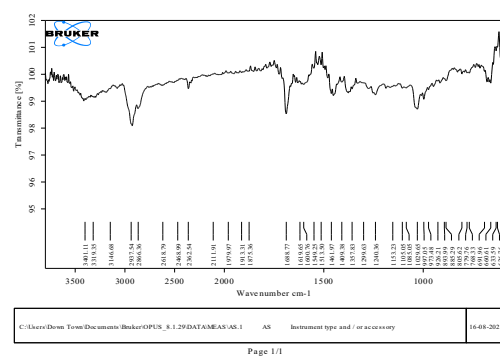


Figure 7: FTIR profiling of different plants fractions and formulation B: Represent the formulation





## Effects of Plyometrics Training on Football Players of Vadodara District

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### ABSTRACT

Plyometrics, also known as jump training or plyos, are exercises in which muscles exert maximum force in short intervals of time. This training focuses on learning to move from a muscle extension to a contraction in a rapid or “explosive” manner, such as in specialized repeated jumping. The first stage of a plyometric movement can be classified as the eccentric phase, but it has also been called the deceleration, loading, yielding, counter movement, or cocking phase. The concentric phase (or unloading phase) occurs immediately after the amortization phase and involves a concentric contraction, resulting in enhanced muscular performance following the eccentric phase of muscle contraction. In soccer rapid movements such as acceleration and deceleration of the body, change of direction, as well as jumps are often performed and high level of dynamic muscular performance is required at all levels of training status. There are various studies which suggest that Plyometrics training helps to improve the strength both static and explosive and also explosive power of muscles

**Keywords:** counter, muscles, concentric, Plyometrics

### INTRODUCTION

Plyometrics, also known as jump training or plyos, are exercises in which muscles exert maximum force in short intervals of time. This training focuses on learning to move from a muscle extension to a contraction in a rapid or “explosive” manner, such as in specialized repeated jumping. [1] The purpose of plyometric training is to increase the power of subsequent movements using both natural elastic components of muscle and tendon and the stretch





Noopur Bhatt et al.,

reflex [2]. Plyometrics are training techniques used by athletes in all types of sports to increase strength and explosiveness [3]. Physical improvements have important implications on team sports, as players perform numerous explosive movements like kicking, tackling, jumping, turning, sprinting, and changing pace and directions during the match thus, plyometric drills usually involve stopping, starting and changing directions in an explosive manner. [4,12]

### THREE PHASES OF PLYOMETRIC EXERCISE

There are three distinct phases involved in plyometric training [11] including the eccentric [15] or loading, phase, the amortization or transition, phase, and the concentric or unloading, phase [5].

#### THE ECCENTRIC PHASE

The first stage of a plyometric movement can be classified as the eccentric phase, but it has also been called the deceleration, loading, yielding, counter movement, or cocking phase. This phase increases muscle spindle activity by pre-stretching the muscle prior to activation. Potential energy is stored in the elastic components of the muscle during this loading phase slower eccentric phase prevents taking optimum advantage of the myostatic stretch reflex. [5]

#### THE AMORTIZATION PHASE

This phase involves dynamic stabilization and is the time between the end of the eccentric contraction (the loading or deceleration phase) and the initiation of the concentric contraction (the unloading or force production phase). The amortization phase, sometimes referred to as the transition phase, is also referred to as the electromechanical delay between the eccentric and concentric contraction during which the muscle must switch from overcoming force to imparting force in the intended direction. A prolonged amortization phase results in less-than-optimum neuromuscular efficiency from a loss of elastic potential energy. A rapid switch from an eccentric contraction to a concentric contraction leads to a more powerful response. [5]

#### THE CONCENTRIC PHASE

The concentric phase (or unloading phase) occurs immediately after the amortization phase and involves a concentric contraction, resulting in enhanced muscular performance following the eccentric phase of muscle contraction. This occurs secondary to enhanced summation and re-utilization of elastic potential energy, muscle potential, and contribution of the myostatic stretch reflex. [5].

### PROPOSED MECHANISM BY WHICH PLYOMETRIC TRAINING ENHANCES

PERFORMANCE: There are three proposed mechanisms by which plyometric training improves performance: enhanced muscle spindle activity, desensitization of the GTO, and enhanced intramuscular and inter muscular neuromuscular efficiency. [5]

#### ENHANCED MUSCLE SPINDLE ACTIVITY

The speed of a muscular contraction is regulated by the neuromuscular system. The human movement system will only move within a set speed range regardless of how strong a muscle is. [5] The faster the eccentric loading, the greater the concentric force production. For example, the quadriceps are loaded more rapidly when dropping from a 1-m box versus a 0.25-m box. [5]

#### DESENSITIZATION OF THE GOLGI TENDON ORGAN

Desensitizing the GTO increases the stimulation threshold for muscular inhibition. This promotes increased force production with a greater load applied to the musculoskeletal system. [5]

#### ENHANCED NEUROMUSCULAR EFFICIENCY

Plyometric training may promote better neuromuscular control of the contracting agonists and synergists, thus





Noopur Bhatt et al.,

enabling the central nervous system to become more reflexive. These neural adaptations lead to enhanced neuromuscular efficiency seen in the absence of morphological adaptations, such as muscle hypertrophy. Exploiting the stretch reflex, inhibiting the GTO, and enhancing the ability of the nervous system to react with maximum speed to the lengthening muscle optimizes the force produced by the concentric contraction. [5]

### PHYSIOLOGICAL PRINCIPLES OF PLYOMETRIC TRAINING

Plyometric training utilizes the elastic and proprioceptive properties of a muscle to generate maximum force production by stimulating mechanoreceptors to facilitate an increase in muscle recruitment in a minimal amount of time. Muscle spindles and Golgi tendon organs (GTOs) [19] provide the proprioceptive basis for plyometric training. The central nervous system then uses this sensory information to influence muscle tone, motor execution, and kinesthetic awareness. Stimulation of

these receptors can cause facilitation, inhibition, and modulation of both agonist and antagonist muscle activity. This enhances neuromuscular [20] efficiency and functional strength. [5] Neuromuscular factors such as increasing the degree of muscle coordination and maximizing the ability to use the muscles stretch-shortening cycle [23,17] appear to be more important for the improvement in jump performance. [6] Plyometric training [14], when used with a periodized strength-training program, can contribute to improvements in vertical jump performance [16], acceleration, leg strength, muscular power, increased joint awareness, and overall proprioception [22]. It includes explosive exercises [10] to activate the quick response and elastic properties of the major muscles. [3] Such plyometric jumps are also used as a warm-up for doing explosive plyometric jumps and for initial preparation of the muscles prior to undertaking exercises such as depth jumps [5].

In soccer rapid movements such as acceleration [18] and deceleration [19] of the body, change of direction, as well as jumps are often performed and high level of dynamic muscular performance is required at all levels of training status. Thus, these plyometric training is a popular among individuals involve in dynamic sports, and plyometric exercise such as jumping [21], hopping, skipping and bounding are executed with a goal to increase dynamic muscular performance [7]. Football, a game in which two opposing teams attempt to score points by moving an inflated oval or round ball past a goal line or into a goal. Differing greatly in their rules, these include soccer (association football) and rugby.

Common rules among the sports include

- Two teams of usually between 11 and 18 players Scoring goals or points by moving the ball to an opposing team's end of the field and either into a goal area, or over a line.
- A clearly defined area in which to play the game.
- Goals or points resulting from players putting the ball between two goalposts.
- The goal or line being defended by the opposing team.
- Players using only their body to move the ball.

The object of football is to outscore your opponents. A goal is scored when the entire ball crosses the goal line between the goal posts. A match consists of two 45 minute periods known as the first and second half. In some instances, extra time can be played, two 15 minute.

### NEED OF STUDY

There are various studies which suggest that Plyometrics training helps to improve the strength both static and explosive and also explosive power of muscles. Studies also suggest that Plyometric improves the endurance of lower limbs and also dynamic performance. There is also literature pertaining the Plyometric training among football players in the age group of up to 25 years and on sports performance. But there is the scarcity of literature showing the effects of short term plyometric training among football players to improve muscle strength and power. This study was therefore undertaken to study the effects of Plyometric training among football players of Vadodara district.







Noopur Bhatt et al.,

### Outcome Measures

Standing broad jump test: it is used to measure the explosive power of lower limb muscles. It is measured as distance hopped in cms the standing broad jump is performed by jumping horizontally from a starting line with a counter movement and the distance covered from the heel of the foot closest to the back of starting line is measured using a measuring tape. Vertical jump height distance: it is used to measure the explosive power of lower limb muscles it is measured as vertical distance in cms. The subject's standing reach is measured by the help of measuring tape then the subjects perform a jump with slight bending from knees and then jump and then mark the wall with chalk at the highest point they reach. The difference between the two distances is determined and used for analysis.

T test: the T-test is used to determine the speed with directional changes such as forward sprinting, left and right side shuffling, and backpedalling. The participant is asked to run from point A to B and then to C to D and then again back to B and A at starting point. The time taken to complete the test was calculated pre and post training in seconds. 30m sprint time: It is used to measure the speed of a player and is measured in seconds. The measuring tape is used to mark the distance and two marking cones are placed at distance of 30 meters. The time taken by the participants to complete 30m is calculated by using a stop watch.

Procedure : Approval from the Gotri Sports complex was obtained for the study with the due permission of Parul University. Non-competitive football players aged upto 25 yrs were screened and reputed based on inclusion and exclusion criteria where 60 subjects are included before participating in the study, the participants were fully informed about the protocol, and return informed consent were obtained from each participant. The participants were free to withdraw from the study at any time. All subjects were divided into 2 groups in a randomized manner by using simple random sampling using computer-generated random numbers method GROUP A (plyometric/experimental training group) and GROUP B (control group).

60 subjects meeting inclusion and exclusion criteria were tested, the subjects were assigned randomly into two groups. GROUP A-were undergone to plyometric training workout and GROUP B- were continuing routine exercise program.

Treatment duration: 3 sessions per week for 4 weeks

Total intervention time: 30 to 60 min

Group A (PTG) consist of 30 football players which were an experimental group and Group B (CG) had another 30 subjects and they were continuing as per their routine. All subjects were continuing their current exercise habits and had not changed or increased exercises during the course of the study. All subjects were instructed not to start any lower extremity strengthening programs during the 4 week period and to only perform activities of normal daily living. The total training session was of 60mins for each subject including warm-up for five minutes, rest time between tests and approximately two minutes between repetitions. Before testing, subjects were given practice trials to familiarise with testing procedures. Uniformity was maintained in the testing sequence at the end of each week. Subjects performed each test 3 times and final recording was done following practice trials. During the training, all subjects were under direct supervision and were instructed how to perform each exercise. Pre intervention assessment (age, height, weight) were taken in both the groups and calculated BMI (body mass index). After the training protocol post assessment data were collected.

The exercises under plyometric training were lateral cone hops, forward cone hops, squat jumps, and box jumps were included while training. Lateral hops were performed with the subjects standing next to a cone with their feet spread shoulder width apart, hopping as high as possible in side to side direction. Forward cone hops were performed with standing in front of the cone with their feet spread apart, the objective was to jump forward direction over the cones as quickly as possible. Squat jumps were performed with the subjects feet facing forward and with shoulder width apart and trunk flexed forward slight with back straight in a neutral position. The lower body where thighs are parallel to ground and immediately explode upwards vertically. Do not hold a squat position before jumping up land on both feet. Rest for 1-2 secs and repeat the jump. Box jumps were performed facing to the

70759





**Noopur Bhatt et al.,**

box with feet slightly wider than hip width apart, lower body into semi-squat position and jump up onto the box. Feet should land softly on the box, step down do not jump back and repeat.

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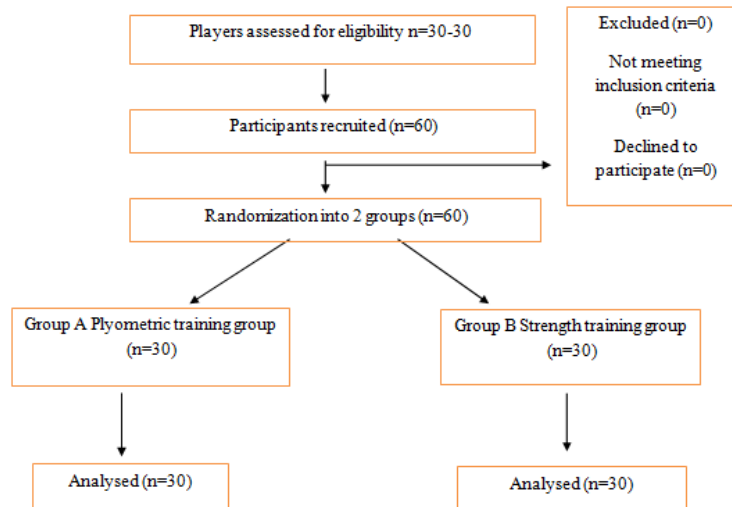
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**Table 1. Plyometrics training protocol**

Training week	Plyometric drills	Sets/reps
1	Lateral hops Forward cone hops Squat jumps Box jumps	1/10
2	Lateral hops Forward cone hops Squat jumps Box jumps	2/20
3	Lateral hops Forward cone hops Squat jumps Box jumps	3/30
4	Lateral hops Forward cone hops Squat jumps Box jumps	4/40



**Flow Chart of the study**





Noopur Bhatt et al.,

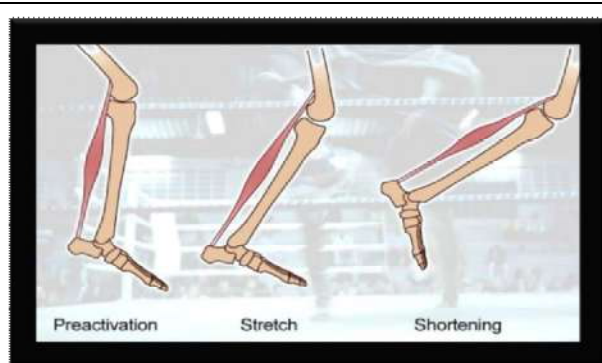


Fig:1-stretch-shortening cycle

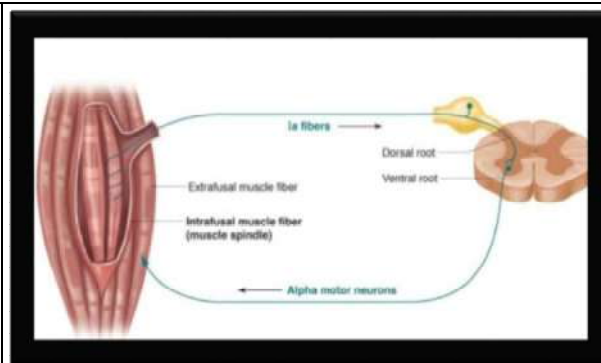


Fig:1-stretch-shortening cycle



Fig:3

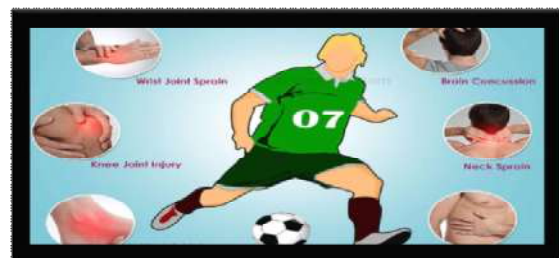


Fig:4: Most common football injuries

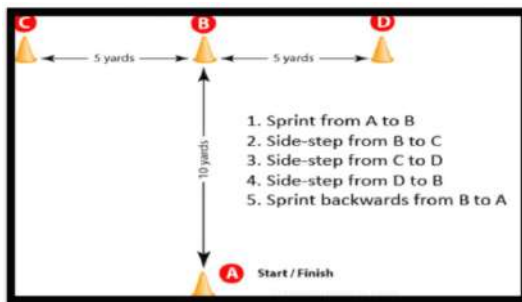


Figure 6: T-test

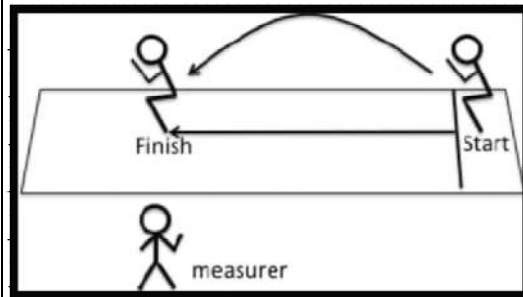


Figure 7: standing broad jump test





Noopur Bhatt *et al.*,





## Molecular Docking Studies of Kojic Acid Derivatives as Anti-Cholinesterase Agents for the Treatment of Alzheimer's Disease

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### ABSTRACT

Alzheimer's disease (AD) is a challenging neurological disorder characterized by memory loss and a slow decline in cognitive function. The World Health Organization (WHO) estimates that 5% of men and 6% of women globally over the age of 60 have Alzheimer's type dementia. A series of kojic acid derivatives were designed and Molecular properties, Toxicity, Molecular Docking and ADME studies were performed in Lipinski Rule of 5 online server, Protox II, PyRx Virtual Screening and Pre-ADMET softwares respectively to investigate the possible molecular properties, toxicities as well as the binding modes of the designed compounds. After performing molecular docking studies of the selected kojic acid derivatives with the protein (PDB code:1EVE), it was found that the designed compounds Comp 1.1, Comp 1.2, Comp 1.4, Comp 1.6, and Comp 1.9 have showed good binding affinities with the protein (1EVE); dock scores of the compounds are found to be -10.8, -10, -10.1, -10.1 and -10.4 (Kcal/mol) respectively. The drug of choice of Alzheimer's disease is Donepezil and the docking scores Donepezil (Comp 1.18) was found to be -11 Kcal/mol. Several bond interactions were observed such as conventional hydrogen bond, pi-pi stacked, pi-alkyl, carbon hydrogen bond, pi-lone pair, pi-sigma, pi-pi-T shaped, Pi doner hydrogen bond etc. So, based on Molecular Properties analysis, Toxicity analysis, ADME analysis and Molecular docking studies it can be concluded that the designed Kojic acid derivatives i.e., Comp 1.1, Comp 1.2, Comp 1.4, Comp 1.6, and Comp 1.9 can be potential candidates for the treatment of Alzheimer's disease and further *In-vivo* and *In- vitro* analysis can be performed to establish the compounds as potent Anti-Alzheimer's agent.





Suman Basak et al.,

**Keywords:** Acetyl cholinesterase enzyme (AChE), Alzheimer's diseases, Molecular Docking, Kojic Acid derivatives.

## INTRODUCTION

Alzheimer disease (AD) clinically manifests as dementia, which typically starts as a mild memory loss that is steadily made worse and, ultimately, becomes incapacitating. These medications slow the disease's development and alleviate symptoms, but they don't completely heal the condition. Although the neuropathological characteristics of Alzheimer's disease are well known, the intricate details of the process are still unclear. The absence of effective treatments that can stop the start and development of the illness may be caused by our incomplete knowledge of the pathogenic process [5]. Plaques and tangles seen in the cerebral cortex are the cause of the clinical form of Alzheimer's disease (AD), which involves permanent and gradual brain function impairment. Alzheimer's symptoms include changes in personality, mood, and behaviour in addition to the deterioration of cognitive and intellectual function. The most frequent cause of dementia is Alzheimer's disease (AD), which is clinically defined by a transition from episodic memory issues to a gradual general decrease in cognitive function. Amyloid plaques and neurofibrillary tangles are the diagnostic indicators of Alzheimer's disease [20]. The cerebral cortex has a widespread degeneration, and the ventricles have secondary enlargement. The hippocampus, temporal cortex, and Meyer net nucleus basalis are where the crystals are most prevalent. There is currently a lot of study being done to clarify the fundamental pathological process that underlies the primary pathological cause of Alzheimer's disease [11,13]. Kojic acid, derived from the mycelium of *Aspergillus oryzae*, was discovered in 1907 by Saito. Its structure was later clarified by Yabuta in 1913. Kojic acid is considered beneficial for health in Japan and can be produced by various microorganisms using various carbohydrate sources. It has a polyfunctional heterocyclic ring, oxygen-containing backbone, and numerous reaction centers[4]. The kojic acid industry has been around since 1955, with Pfizer and American companies attempting to make it. Kojic acid is also used as an anti-inflammatory and analgesic in medicine, as well as an antioxidant agent in agricultural products and food. The demand for kojic acid has increased due to its numerous applications [8]. Molecular Docking has evolved over the last thirty years as a consequence of structural molecular biology and drug discovery based on structure constraints. It has been greatly helped by the massive increase in computer access and capability, as well as the growing simplicity with which minuscule molecule and protein collections can be found [3,18]. The goal of computerised docking apps is to understand and predict molecular recognition, both structurally and energetically, by finding likely binding modes and calculating binding affinity. Molecular docking is usually performed with minuscule molecules and a macromolecule as a target. Although ligand-protein docking is more frequently used, protein-protein docking is getting popularity. A few of the numerous uses and applications for molecular docking in drug discovery include structure-activity studies, lead optimization, virtual screening for potential leads, providing binding hypotheses to aid in predictions for mutagenesis research, assisting x-ray crystallography in fitting substrates and inhibitors to electron density measurements, chemical-based mechanism studies, and combinations library design [13]. Additionally, there are some programmes that are used mainly to implement high throughput docking models, like DOCK, GOLD, FlexX, PyRx Virtual Screening and ICM. Depending on the goals of the docking models, there are different types of molecular docking techniques using either flexible or rigid ligand/target combinations. Flexible Ligand Docking - which includes the stiff molecular target, Rigid Body Docking - where the molecules of the target and drug are kept stiff, Flexible Docking - that includes both bendable and interacting components [18].

## MATERIALS AND METHODS

### Collection and Preparation of the Compounds to Build the Library

In this study, different published articles were taken for the selection of the Kojic Acid derivatives. Total 45 Kojic acid derivatives were selected for the building the library. The 2D structures of the selected compounds were designed in CHEM DRAW 21.0.0 software and saved as “.cdxml” format as well as “.sdf” file format for future use.







Suman Basak et al.,

### Molecular Property Analysis of the Compounds

The Lipinski Rule of Five is useful for identifying compounds that are drug-like and those that are not. Due to the similarity of the molecules to drugs and their compliance with two or more of the following conditions, it forecasts high chance of success or failure-

- ✓ Molecular mass less than 500 D.
- ✓ Less than 5 hydrogen bond donors.
- ✓ Less than 10 hydrogen bond acceptors.
- ✓ High lipophilicity (expressed as Log P < 5).
- ✓ Molar refractivity should be between 40-130.

The drug likeness analysis of the selected Kojic acid derivatives was done using the Lipinski rule of 5 online server which is created by IIT, Delhi online server (<http://www.scfbio-iitd.res.in/software/drugdesign/lipinski.jsp>). Here the “.sdf” file of the derivatives were entered in the online server and the above mentioned several parameters were evaluated and the derivatives were segregated for the further analysis.

### Toxicity Analysis of the Compounds

The toxicity analysis of selected Kojic acid derivatives was done in PORTOX-II online software ([https://tox-new.charite.de/protox\\_II/](https://tox-new.charite.de/protox_II/)). The compounds were converted into SMILES format and the SMILES format of the individual compounds were given in the software for the toxicity analysis. In the toxicity analysis several toxicities are evaluated –

- ✓ Hepatotoxicity
- ✓ Carcinogenicity
- ✓ Immunotoxicity
- ✓ Mutagenicity
- ✓ Cytotoxicity

### Selection and Preparation of Acetylcholinesterase Protein

The X-ray crystal structure of the target protein (1EVE) were downloaded from the Protein Data Bank website ([www.rcsb.org](http://www.rcsb.org)). The crystal structure was selected for the study on the basis of the Resolution, **R-Value Free**, **R-Value Work**, **R-Value Observed**. *Kryger, G., Silman, I., Sussman, J.L.*, modelled and refined the structure by indicating the active binding site for the In silico study. To prepare the target protein for the docking study, the protein was loaded in the Discovery Studio (DS 2021) software. In the DS 2021 software the additional ligand molecules, the hetero atoms and the water molecules were removed and the protein molecule is saved for the further docking analysis as “.pdb” format.

### Molecular Docking Analysis of the Compounds

Docking was performed between ligand compounds and protein molecules using PyRx virtual screening software. The grid box center values for 1EVE receptor were kept as X:4.212466021, Y:65.70114607, and Z:56.21270435, whereas the grid box size values for 1EVE receptor were kept as X:65.86003117, Y:71.46227187, Z:59.09512809. The ligand posture provided the lowest binding energy when docking was complete, and Discovery Studio 2021 was then used to visualize the interaction between the ligand and protein [1].

### ADME Analysis of the Compounds

To predict absorption, distribution, metabolism, excretion (ADME) for the selected Kojic acid derivatives Per ADMET online software online software (<https://preadmet.webservice.bmdrc.org/adme/>) were applied. The compounds were converted into “.mol” format and the mol text was entered into this abovementioned software and several parameters were evaluated like- Caco-2 cells, high human oral absorption, protein binding plasma, CYP3A4, CYP2C19, CYP2D6, CYP3A4 and BBB [1].





Suman Basak et al.,

## RESULTS AND DISCUSSIONS

### Molecular Properties Analysis

Among the 45 Kojic derivatives, 17 Kojic acid derivatives were selected with a very high Molecular properties values or the compounds which are following the Lipinski Rule of Five i.e., hydrogen bond doner <5, hydrogen bond acceptor <10, Molecular mass <500D, Log P value <5 and Molar refractivity value in between the range 30-120. The Molecular properties score details of the individual compounds are summarized in Table 2.

### Toxicity Analysis

The Toxicity Analysis of the selected compounds were performed by using PROTOX II online software in which the several toxicities parameters like Hepatotoxicity, Carcinogenicity, Immunotoxicity, Mutagenicity, Cytotoxicity of the compounds were evaluated. In the toxicity analysis studies the drug Donepezil which is considered as the drug of choice of Alzheimer's disease was found toxic like- Carcinogenicity, Immunotoxicity, Cytotoxicity. The rest of the 17 compounds was found Inactive toxicities in this analysis. The toxicity analysis score details were summarized in Table 3.

### Molecular Docking Analysis

1-((3-hydroxy-6-(hydroxymethyl)-4-oxo-4H-pyran-2-yl)methyl)-4-phenylpiperidine-4-carbonitrile (Comp1.1) was speculated to have maximum binding affinity (-10.8 kcal/mol) with 1EVE receptor with 17 hydrogen bond interaction via TYRA:334, PHEA:331, PHEA:290, PHEA:330, SERA:200, GLYA:118, HISA:440, GLYA:119, TRPA:84, TYPA:70, PROA:86, ASNA:85, GLNA:69, GLYA:123, SERA:123, ASPA:72, TYRA:121. 2-((4-(4-bromophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one (Comp1.2) was speculated to have maximum binding affinity (-10kcal/mol) with 1EVE receptor with 5 hydrogen bond interactions via HISA:440, TRPA:84, PHEA:330, TYRA:334, PHEA:331. 2-((4-(4-chlorophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one (Comp 1.4) was speculated to have the maximum binding affinity (-10.1kcal/mol) with 1EVE receptor with 17 hydrogen bond interactions via HISA:440, GLYA:441, GLUA:199, ILEA:444, TRPA:84, TYPA:130, GLYA:118, GLYA:123, ASPA:72, GLYA:117, PHEA:330, TYPA:334, TYRA:121, PHEA:331, GLYA:335, ILEA:287, PHEA:288. 2-((4-chlorophenoxy)methyl)-5-hydroxy-4H-pyran-4-one (Comp 1.6) was speculated to have the maximum binding affinity (-10.1kcal/mol) with 1EVE receptor with 11 hydrogen bond interactions via PHEA:331, TYRA:334, PHEA:330, GLYA:118, TYPA:130, GLYA:117, GLUA:199, ILEA:444, GLYA:441, TRPA:84, HISA:440. 3-hydroxy-2-((4-hydroxy-4-phenylpiperidin-1-yl)methyl)-6-methyl-4H-pyran-4-one (Comp 1.9) was speculated to have the maximum binding affinity (-10.4kcal/mol) with 1EVE receptor with 18 hydrogen bond interactions via PHEA:288, ILEA:287, PHEA:290, TYRA:121, GLUA:199, ILEA:444, GLYA:441, TYRA:130, GLYA:117, GLY123, SERA122, TRPA:84, GLYA:118, PHEA:330, HISA:440, PHEA:331, TYRA:334, GLYA:335, Donepezil (Comp 1.18) was speculated to have the maximum binding affinity (-11kcal/mol) with 1EVE receptor with 16 hydrogen bond interactions via LEUA:282, TRPA:279, PHEA:288, ILEA:287, TRPA:84, PHEA:330, HISA:440, ASNA:85, SERA:81, ASPA:72, TYRA:121, TYRA:334, PHEA:331, PHEA:290, ARG:289, SERA:286. It seems that the Comp 1.1, Comp 1.2, Comp 1.4, Comp 1.6 and Comp 1.9 shows a satisfactory binding affinity toward the 1EVE protein as compared to the drug of choice donepezil. The interactions were shown in Figure 2 as well the Docks score of all the compounds were summarized in Table 4.

### ADME Analysis

CNS drugs need to orally absorb and cross the blood brain barrier (BBB) to treat chronic neurodegenerative diseases. For this purpose, they must be having particular physicochemical properties than peripheral drugs, including weight (MW), the number of hydrogen bond donor (HBD) and/or as acceptor (HBA), partition coefficient (logP). To predict absorption, distribution, metabolism, excretion, and toxicity (ADMET) of selected compounds, online software PreADMET (<https://preadmet.webservice.bmdrc.org/adme/>) was applied and the results presented in Table 5. These Kojic acid derivatives compounds have moderate permeability to Caco-2 cells, high human oral absorption, and protein binding plasma. These compounds are non-inhibitors of CYP3A4, CYP2C19, and CYP2C9 and inhibitor of





Suman Basak et al.,

CYP2D6 and probably substrate for CYP3A4 and CYP2D6. It seems that compounds Comp 1.1, Comp 1.2, Comp 1.4, Comp 1.6, and Comp 1.9 satisfactory pass from BBB. According to predictions of the ADME properties, it can be proposed that the selected potent compounds (Comp 1.1, Comp 1.2, Comp 1.4, Comp 1.6, and Comp 1.9) may have a good pharmacokinetic profile. The ADME results of all the compounds were summarized in Table 5.

## CONCLUSION

The Kojic acid derivatives were designed, and evaluated as anti-AChE agents compared with Donepezil. All compounds produced moderate to good inhibitory activity against AChE protein. The results of molecular properties, toxicity, molecular docking studies and ADME analysis demonstrated that the compounds 1-((3-hydroxy-6-(hydroxymethyl)-4-oxo-4H-pyran-2-yl)methyl)-4-phenylpiperidine-4-carbonitrile (Comp1.1), 2-((4-(4-bromophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one (Comp 1.2), 2-((4-(4-chlorophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one (Comp 1.4), 2-((4-chlorophenoxy)methyl)-5-hydroxy-4H-pyran-4-one (Comp 1.6), 3-hydroxy-2-((4-hydroxy-4-phenylpiperidin-1-yl)methyl)-6-methyl-4H-pyran-4-one (Comp 1.9) have good inhibitory potential with AChE protein. *In silico* prediction of ADMET also suggested a good pharmacokinetic profile. These findings indicate the therapeutic potential candidates of kojic acid derivatives as anti-AD agents.

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Table 1. List of the Kojic Acid Derivatives

Code	Structure	Name
Comp 1.1		1-((3-hydroxy-6-(hydroxymethyl)-4-oxo-4H-pyran-2-yl)methyl)-4-phenylpiperidine-4-carbonitrile
Comp 1.2		2-((4-(4-bromophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one
Comp 1.3		2-((4-(4-chlorophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-(hydroxymethyl)-4H-pyran-4-one
Comp 1.4		2-((4-(4-chlorophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one





Suman Basak et al.,

Comp 1.5		2-((4-(4-fluorophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one
Comp 1.6		2-((4-chlorophenoxy)methyl)-5-hydroxy-4H-pyran-4-one
Comp 1.7		2-((benzyloxy)methyl)-5-hydroxy-4H-pyran-4-one
Comp 1.8		3-hydroxy-2-((4-(4-iodophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-6-methyl-4H-pyran-4-one
Comp 1.9		3-hydroxy-2-((4-hydroxy-4-phenylpiperidin-1-yl)methyl)-6-methyl-4H-pyran-4-one
Comp 1.10		3-hydroxy-6-(hydroxymethyl)-2-((4-(4-iodophenyl)piperazin-1-yl)methyl)-4H-pyran-4-one
Comp 1.11		3-hydroxy-6-methyl-2-((4-(4-(trifluoromethyl)phenyl)piperazin-1-yl)methyl)-4H-pyran-4-one
Comp 1.12		5-hydroxy-2-(((tetrahydro-2H-pyran-2-yl)oxy)methyl)-4H-pyran-4-one
Comp 1.13		5-hydroxy-2-((phenylthio)methyl)-4H-pyran-4-one
Comp 1.14		5-hydroxy-2-phenethyl-4H-pyran-4-one
Comp 1.15		6-chloro-2-((4-(2-fluorophenyl)piperazin-1-yl)methyl)-3-hydroxy-4H-pyran-4-one





Suman Basak et al.,

Comp 1.16		6-chloro-2-((4-(3,4-dichlorobenzyl)piperazin-1-yl)methyl)-3-hydroxy-4H-pyran-4-one
Comp 1.17		6-chloro-2-((4-(4-fluorobenzyl)piperazin-1-yl)methyl)-3-hydroxy-4H-pyran-4-one
Comp 1.18		Donepezil

Table 2. Results of Molecular Properties Analysis

Code	Mass	HBD	HBA	Log P	Molar refractivity
Comp 1.1	320.00	2	4	-1.542910	65.051498
Comp 1.2	357.00	1	3	-0.98960	63.955498
Comp 1.3	329.50	2	4	-1.657500	62.645500
Comp 1.4	313.500	1	3	-1.145360	60.881500
Comp 1.5	297.00	1	3	-1.701050	55.624500
Comp 1.6	243.500	1	4	-1.360620	41.942005
Comp 1.7	220.000	1	4	0.000000	0.000000
Comp 1.8	406.000	1	3	-0.593180	70.382500
Comp 1.9	294.000	2	4	-0.858610	58.751999
Comp 1.10	425.000	2	4	-0.955300	73.705498
Comp 1.11	349.000	1	3	-0.288680	61.224503
Comp 1.12	212.000	1	5	0.00000	0.000000
Comp.1.13	224.000	1	3	-1.035330	44.3998505
Comp 1.14	204.000	1	3	-0.514330	39.315502
Comp 1.15	322.5000	1	3	-0.192000	61.484501
Comp 1.16	386.5000	1	3	-0.243250	71.347488
Comp 1.17	334.5000	1	3	-1.464940	62.370495
Comp 1.18	350.000	0	3	-1.292900	72.556496

**Abbreviations:** HBD- Hydrogen Bond Doner, HBA- Hydrogen Bond Acceptor.

Table 3. Results of Toxicity Analysis

Codes	Toxicities				
	Hepatotoxicity	Carcinogenicity	Immunotoxicity	Mutagenicity	Cytotoxicity
Comp 1.1	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.2	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.3	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.4	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.5	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.6	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE







Suman Basak et al.,

Comp 1.7	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.8	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.9	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.10	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.11	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.12	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.13	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.14	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.15	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.16	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.17	INACITIVE	INACTIVE	INACTIVE	INACTIVE	INACTIVE
Comp 1.18	INACITIVE	ACTIVE	ACTIVE	INACTIVE	ACTIVE

Table 4. Results of Molecular Docking Analysis

Codes	Dock Scores	Center			Size		
		X	Y	Z	X	Y	Z
Comp 1.1	-10.8	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.2	-10	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.3	-9.9	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.4	-10.1	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.5	-9.3	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.6	-10.1	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.7	-8.8	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.8	-8.8	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.9	-10.4	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.10	-9.5	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.11	-9.6	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.12	-10.3	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.13	-7.9	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.14	-8.8	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.15	-9.2	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.16	-9.8	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.17	-9.4	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809
Comp 1.18	-11	4.212466021	65.70114607	56.21270435	65.86003117	71.46227187	59.09512809

Table 5. Results of ADME analysis:

Codes	Caco-II [a]	HIA% [a]	PBP% [a]	CYP3A4 substrate	CYP3A4 inhibition	CYP2C1 9 inhibition	CYP2D6 substrate	CYP2D6 inhibition	CYP2C9 inhibition	BBB score[a]
Comp 1.1	50.085	93.309	82.437	Weakly	Non	Non	Substrate	Inhibitor	Non	0.1752
Comp 1.2	45.096	96.267	98.267	Weakly	Non	Non	Substrate	Inhibitor	Non	0.2061
Comp 1.3	22.065	94.145	84.006	Substrate	Non	Non	Substrate	Inhibitor	Non	0.1851
Comp 1.4	49.948	95.348	91.345	Weakly	Non	Non	Substrate	Inhibitor	Non	0.1796
Comp 1.5	47.967	95.529	69.104	Weakly	Non	Non	Substrate	Inhibitor	Non	0.088
Comp 1.6	33.413	95.508	84.328	Weakly	Non	Non	Substrate	Inhibitor	Non	0.1776
Comp 1.7	12.115	95.228	68.647	Weakly	Non	Inhibitor	Non	Non	Inhibitor	0.243 1
Comp 1.8	31.564	97.181	100	Weakly	Non	Non	Substrate	Inhibitor	Non	9.0528
Comp 1.9	50.353	93.103	81.444	Weakly	Non	Non	Substrate	Inhibitor	Non	0.145 1
Comp 1.10	22.399	96.528	73.945	Weakly	Non	Non	Substrate	Non	Non	0.0585
Comp 1.11	27.818	95.556	66.789	Weakly	Non	Non	Substrate	Non	Non	0.0973
Comp 1.12	20.210	90.703	52.567	Weakly	Non	Inhibitor	Non	Non	Inhibitor	0.0115
Comp.1.13	24.496	96.357	74.293	Non	Non	Inhibitor	Non	Non	Inhibitor	0.4666





Suman Basak et al.,

Comp 1.14	3.728	95.003	100	Non	Non	Inhibitor	Non	Non	Inhibitor	0.3485
Comp 1.15	28.793	95.725	58.9306	Weakly	Non	Non	Substrate	Non	Non	0.0702
Comp 1.16	41.236	96.648	80.3328	Weakly	Non	Non	Substrate	Inhibitor	Non	0.3579
Comp 1.17	30.991	95.786	57.2972	Weakly	Non	Non	Substrate	Inhibitor	Non	0.0705
Comp 1.18	55.514	97.951	84.6158	Weakly	Non	Non	Substrate	Inhibitor	Non	0.1879

[a] Abbreviations: ADME: absorption, distribution, metabolism, excretion; HIA: Human oral absorption; PBP: protein-binding plasma. The recommended range for Caco-2:<4 is poor and >70 is great; HIA:>80% is high and <25% is poor; and PBP:>80% is high and <25% is poor; Low absorption to CNS, <0.1 is low and >2 is high.

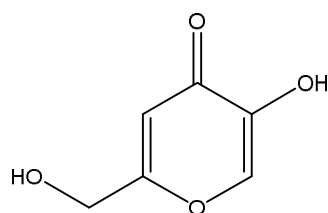


Figure 1. Kojic Acid

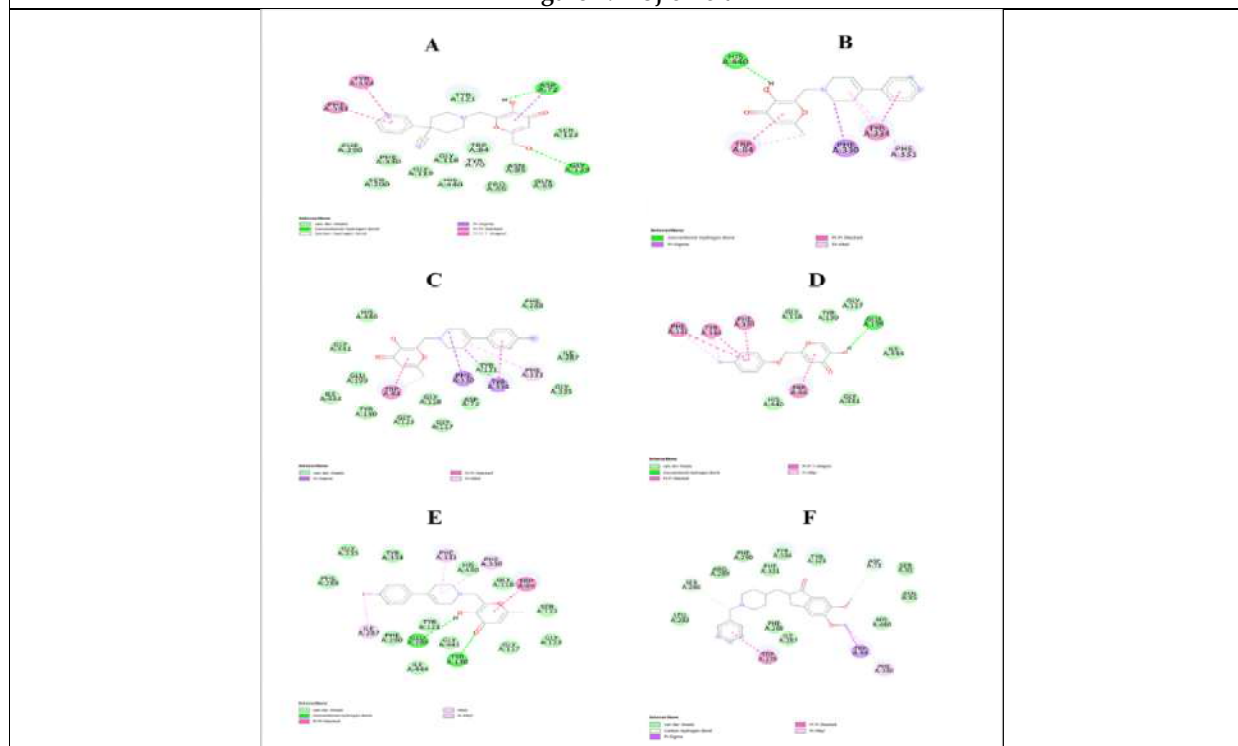


Figure 2. Interaction of A: 1-((3-hydroxy-6-(hydroxymethyl)-4-oxo-4H-pyran-2-yl)methyl)-4-phenylpiperidine-4-carbonitrile with 1EVE protein. B: 2-((4-(4-bromophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one with 1EVE protein. C: 2-((4-(4-chlorophenyl)-3,6-dihydropyridin-1(2H)-yl)methyl)-3-hydroxy-6-methyl-4H-pyran-4-one with 1EVE protein. D: 2-((4-chlorophenoxy)methyl)-5-hydroxy-4H-pyran-4-one with 1EVE protein. E: 3-hydroxy-2-((4-hydroxy-4-phenylpiperidin-1-yl)methyl)-6-methyl-4H-pyran-4-one with 1EVE protein. F: Donepezil with 1EVE protein.





## Development and Evaluation of Cevimeline HCl Controlled Release Microcapsules using Natural Polymers

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### ABSTRACT

The goal of the current work is to develop and evaluate Cevimeline HCl controlled release microcapsules employing guar gum and copal gum as polymers and sodium alginate as encapsulating agents and calcium chloride as a cross-linking agent. Cevimeline is used to treat the symptoms of dry mouth in patients with Sjogren's syndrome. In the present research work, cevimeline controlled release microcapsules were prepared by natural polymers like Guar gum and Copal gum. The main objective of the present study was to develop cevimeline controlled release microcapsules and to control the release of drug using natural polymers. The ionic gelation method was used to prepare and formulate cevimeline HCl microcapsules. Flow properties such as angle of repose, compressibility index, particle size, encapsulation efficiency, and drug release profiles were determined in the prepared microcapsules. Angle of repose, compressibility index, % drug content, encapsulation efficiency, and particle size were all measured in the prepared microcapsules. All of the flow properties were within the IP limits. The drug content of microcapsules prepared by the ionic gelation method was found to be in the range of 92 to 98% by varying the polymeric concentration. Cevimeline HCl controlled release microcapsules were found to have an encapsulation efficiency ranging from 45 to 68%. Among all formulations tested, formulation C8 prepared with 30 mg of copal gum should controlled the 92.11% drug release over a 12-hour period and was found to be suitable for extending drug release up to 16 hours. The ionic gelation method was used to prepare cevimeline HCl controlled release microcapsules, which is a novel



**Balakrishna et al.,**

formulation that can help treat Cevimeline is used to treat the symptoms of dry mouth in patients with Sjogren's syndrome.

**Keywords:** Cevimeline HCl, Guar gum, Copal gum, microcapsules and Ionic gelation method.

## INTRODUCTION

The primary goal of a controlled drug delivery system is to achieve pass ability and increased bioavailability (Nath et al., 2009). Various techniques for modifying drug release profiles in terms of time and action are now available. There are numerous carrier drug delivery systems available, including microcapsules, microspheres, nanoparticles, nanosomes, phytosomes, and niosomes, and we chose one that uses microcapsules as drug carriers. These carrier systems are widely used to mask drug molecules' taste and odour, prolong drug release, improve drug molecule stability, and increase bioavailability. (Khamanga, 2009; Belgamwar, 2008; Shabaraya et al., 2009). Cevimeline Hydrochloride is cholinergic agents that stimulates the secretion of exocrine glands such as salivary and sweat glands. Cevimeline Hydrochloride is used to treat dry mouth symptoms in Sjogren's syndrome (Wieland et al., 2002). It is taken orally as a 30 mg capsule three times a day. With a mean time to peak concentration of 1.5 to 2 hours after a single dosage administration, it can be rapidly absorbed.

After the administration of numerous doses, neither the active medication nor its metabolites accumulate. (Yamada et al., 2005). The ability of polyelectrolytes to cross link in the presence of counter ions to form beads, also known as microcapsules, is central to ionotropic gelation. These are spherical hydrophilic cross-linked polymeric molecules capable of high gelation and swelling in all biological fluids, with polymer relaxation controlling drug release. Microcapsules are formed by dropping a drug-loaded polymeric solution into an aqueous solution of polyvalent cations. Cations diffuse into drug-loaded polymeric drops, forming an ionically cross linked moiety lattice in three dimensions. (Bolourtchian, 2005; Haznedar et al., 2004). Thus, the current study was primarily concerned with the design and development of Cevimeline HCl controlled release microcapsules via ionic gelation using guar gum and copal gum as polymers, sodium alginate and calcium chloride as encapsulating materials, and calcium chloride as a cross-linking agent. To investigate the impact of preparation method on the physical properties and drug release profiles of Cevimeline HCl controlled release microcapsules moiety (Horoz et al., 2004).

## MATERIALS AND METHODS

### Materials

Cevimeline HCl is a free sample provided by Aurobindo Pharma Limited in Hyderabad (India). Guar gum and copal gum were purchased commercially from Yarrow Chemical Products in Mumbai. Colorcon chemicals Asia Pvt, Ltd., Mumbai, supplied the croscarmellose sodium, sodium alginate, and calcium chloride.

### Ionic Gelation Method for Preparing Cevimeline HCl Controlled Release Microcapsules

Ionic gelation was used to prepare Cevimeline HCl controlled release microcapsules. By stirring with a magnetic stirrer, in 25 ml of distilled water, sodium alginate (2% w/w) was dissolved. Cevimeline HCl and polymers were added to the sodium alginate mixture and stirred for 5-10 minutes at 1000 rpm to achieve a homogeneous mixture. After waiting for the air bubbles to disappear completely, the mixture was dropped into 50 ml of 5% calcium chloride solution drop by drop. After one hour of curing, the calcium chloride solution was decanted, and the beads were filtered and air dried. (Dong, 2006; Hemalatha et al., 2010). The composition of Cevimeline HCl controlled release microcapsules were given in Table 1.





Balakrishna et al.,

### Evaluation of Cevimeline HCl Controlled Release Microcapsules

The flow properties of the prepared microcapsules, such as angle of repose and compressibility index, as well as the drug content, encapsulation efficiency, and particle size, were evaluated (Suganeswari, 2011; Bonello et al., 2014). The results were showed in Table 2.

#### Angle of Repose

To ascertain if the material flow was good or bad, the powder flow characteristics were examined. A funnel was used to pour the powder through. This was covered with a graph sheet to create a heap-like structure, and the heap's height and radius were measured. Utilizing the formula, the angle of repose was computed. based on these;

$$\theta = \tan^{-1}(h/r)$$

#### Compressibility Index

By comparing a powder's poured density and tapped density as well as the rate at which it is packed, a compressibility index was utilized to assess a powder's ability to flow. down.

$$\text{Carr's Index} = \frac{\text{Tapped density} - \text{Poured density}}{\text{Tapped density}} \times 100$$

#### Drug Content

By crushing a known quantity of microcapsules in a mortar and pestle and soaking them in 100 ml of 6.8 pH phosphate buffer for 60 minutes while stirring continuously, it was possible to calculate the amount of medication present in the microcapsules. The microcapsules entirely swelled and ruptured as a result of this. The resultant dispersion was filtered through a 0.45 m membrane filter after the proper dilution with 6.8 pH phosphate buffer, and the drug concentration in the solution was assessed spectro photometrically.

#### Encapsulation Efficiency

Microcapsules of cevimeline HCl were chosen at random from a batch and ground into a powder. A 100 ml volumetric flask containing the powdered substance and 70 ml of 6.8 pH phosphate buffer was used. After roughly 30 minutes of shaking every 30 minutes, 100 ml of 6.8 pH phosphate buffer was added and the volume was raised. The solution from the volumetric flask was centrifuged a total of 10 ml. The centrifuge tube's supernatant solution was removed, collected, and put through another millipore filtering process. After diluting the filtrate, the absorbance at 254 nm was calculated. (Kuang, 2018; Raditya et al., 2017). For each batch of microcapsules, this test was repeated six times (N= 3).

#### Particle Size Determination

The release characteristics of microcapsules are greatly influenced by their size distribution. The microscopic approach was utilized to analyze the average particle size of microcapsules. For this research, the particle size of 100 microcapsules was measured using a calibrated optical microscope.

#### In vitro Dissolution Studies

For each batch of microcapsules, dissolution studies were carried out using 900 ml of 6.8 pH phosphate buffer as the dissolution medium in a calibrated 8 station dissolution test apparatus (LABINDIA DS 8000), according to the USP apparatus II . Up to 12 hours, samples were taken out at regular intervals. To keep the volume constant throughout the experiment, fresh medium volume was added in place of the withdrawn volume. Samples taken out were properly diluted in the same dissolution medium, and an ELICO double beam spectrophotometer was used to measure the amount of drug released at 254 nm. Different in vitro dissolution parameters, including first order, higuchi, and koresmeyer peppa's constant, were calculated based on the results. The drug release profiles of various controlled release microcapsules of Cevimeline HCl were shown in Fig1. The dissolution parameters were showed in Table 3.

#### Characterization Studies

The optimized formulations were chosen based on the results of the dissolution studies, and Fourier Transform Infrared (FTIR) and Differential Scanning Calorimetry (DSC) studies were performed to observe the drug-polymer



**Balakrishna et al.,**

interactions. To determine the surface characteristics of Cevimeline HCl pure drug and optimized formulation C8, SEM analysis was performed. The results were shown in Fig 2 to 9.

## RESULTS

### Preparation of Cevimeline HCl Controlled Release Microcapsules by Ionic Gelation Method

Cevimeline HCl controlled release microcapsules were developed in the current study using the ionic gelation method. As controlled release coating polymeric materials, Guar gum and copal gum were used to prepare microcapsules. As cross-linking and encapsulating agents, sodium alginate and calcium chloride were employed. The compositions of various controlled release microcapsules of Cevimeline HCl were showed in Table 1.

### Evaluation of Physical Parameters of Cevimeline HCl Controlled Release Microcapsules

Angle of repose, compressibility index, and percentage of drug content, encapsulation efficiency, and particle size were all assessed for the manufactured microcapsules. The physical parameters evaluated for various microcapsules were given in Table 2.

### In vitro Dissolution Studies of Cevimeline HCl Controlled Release Microcapsules

In vitro dissolution studies of all the formulations of Cevimeline HCl controlled release microcapsules were performed using an eight station dissolution test device with paddles and 900 ml of a 6.8 pH phosphate buffer as the dissolution medium. The *in vitro* dissolution parameters of all the formulations and drug release profiles for various microcapsules were shown in Table 3 and Fig 1.

### Characterization of Microcapsules

The optimized formulations were chosen and subjected to characterization studies such as FTIR, DSC and SEM analysis.

### Fourier-Transform Infra Red (FT-IR) Spectroscopic Analysis

The FTIR studies were subjected to drug, polymers and optimized formulation C8. The spectrums were shown in Fig's 2 to 5.

### Differential Scanning Calorimetry

The DSC studies were conducted for pure drug and the optimized formulation C8. The thermograms were shown in Fig's 6 & 7.

### Scanning Electron Microscopy

The SEM analysis was conducted for pure drug and the optimized formulation C8. The SEM photographs were shown in Fig's 8 & 9.

## DISCUSSION

Based on the above results, the obtained angles of repose values for different microcapsules were in the range of 23.14° to 25.76°, indicating that microcapsules had good flow characteristics. The obtained compressibility index for different microcapsules ranged from 11.25 to 15.35%, indicating good flow characteristics of microcapsules. By using a simple microscopic technique, the average particle size was found to be in the range of 144 to 164 μm for all formulations. It was proved that the drug content of microcapsules made using the ionic gelation process ranged from 92-98%. Cevimeline HCl controlled release microcapsules were reported to have encapsulation efficiency between 45 and 68%. Among these, C8 showed more encapsulation efficiency which is a prime feature for the preparation of microcapsules. All of the microcapsules were subjected to in vitro dissolution tests using an eight





**Balakrishna et al.,**

station dissolution test device with paddles and 900 ml of a 6.8 pH phosphate buffer as the dissolving medium. Without polymers, formulations C1 to C2 were found to release 99.12% of the drug within 6 hours and failed to control the drug release. Guar gum was used in the preparation of Formulations C3 to C5 at concentrations between 10 and 30 mg, and results showed 99.74% drug release for 8 to 12 hours. 99.36% drug release was observed in formulations C6 to C8 prepared with Copal gum at concentrations between 10 and 20 mg for 8 to 12 hours.

Formulation C8 was found to be suitable for extending drug release up to 16 h, showing about 92.11% of drug release over a period of 12 h. Drug diffusion from the polymeric matrix was followed by polymer erosion. All the microcapsule formulations were observed to have first order release rates that were linear, with R2 values between 0.919 and 0.986. As a result, the rates of drug release from all microcapsule formulations were dependent on concentration and linear with the first order release rate constant (K1). All the microcapsule formulations were observed to be linear with the Higuchi constant, with R2 values ranging from 0.911 to 0.998. Diffusion was used to determine the rates of drug release from each microcapsule composition. All the microcapsule formulations' release exponents (n values) from Peppas's plot ranged from 0.518 to 0.877, showing that the drug release was not caused by Fickian diffusion. The principal peaks were visible in the FTIR spectra of cevimeline HCl at wave numbers 3640 cm<sup>-1</sup> (O-H), 1700 cm<sup>-1</sup> (C=O), and 1252 cm<sup>-1</sup> (C-O). Peaks were seen at 2556 cm<sup>-1</sup> (C-H), 3245 cm<sup>-1</sup> (O-H), 1130 cm<sup>-1</sup> (C-O-C), and 1511 cm<sup>-1</sup> (C=O) for Guar gum. Peaks were seen for copal gum at 2333 cm<sup>-1</sup> (C-H), 3221 cm<sup>-1</sup> (O-H), and 1004 cm<sup>-1</sup> (C-O-C). Peaks were seen for sodium alginate at 2950 cm<sup>-1</sup> (C-H), 3420 cm<sup>-1</sup> (O-H), 1032 cm<sup>-1</sup> (C-O-C), and 1650 cm<sup>-1</sup> (C=O). All the major peaks found in the Cevimeline HCl pure drug were seen in the spectra of the optimized microcapsules C8. As a result, no distinctive peak appeared or vanished, proving that there is no chemical interaction between the drug and the employed polymer. The sharp endothermic DSC thermo graphic peak for cevimeline HCl was found at 205.6°C. The large endothermic DSC thermo graphic peak for the improved formulation C8 was observed at 133.38°C. The findings showed that there were no significant interactions between the drug and the polymers. Some of the microcapsules prepared using the ionic gelation process undergone to SEM examination. The studies showed that the pure drug showed irregular powder crystals in the SEM IMAGE. Where as optimized formulation C8 showed prepared microcapsules were found to be uniform and spherical in nature.

## CONCLUSION

To produce a sustained therapeutic impact by constantly releasing the drug over a longer period, the idea of developing microcapsules containing cevimeline HCl offers a viable, practical solution. So, employing varied concentrations of the polymers guar gum and copal gum, the ionic gelatin technique was effectively used to prepare the microcapsules of cevimeline HCl.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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## Balakrishna et al.,

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**Table 1: Composition of Cevimeline HCl controlled release microcapsules**

Ingredients (mg)	C1	C2	C3	C4	C5	C6	C7	C8
Cevimeline HCl	30	30	30	30	30	30	30	30
Gaur gum	-	-	10	20	30	-	-	-
Copal gum	-	-	-	-	-	10	20	30
Sodium Alginate	15	25	50	50	50	50	50	50
Calcium Chloride (5%)	5%	5%	5%	5%	5%	5%	5%	5%
Water	50	50	50	50	50	50	50	50

**Table 2: Evaluation of Cevimeline HCl controlled release microcapsules**

Formulation	Angle of repose ( $\theta$ )	Compressibility Index (%)	Hausner's ratio	Drug content (%)	Entrapment Efficiency (%)	Particle shape ( $\mu\text{m}$ )
C1	23.14±0.02	11.25±0.051	1.222±0.05	98±0.02	45±0.06	144±0.07
C2	21.94±0.05	12.40±0.024	1.142±0.07	93±0.02	48±0.05	147±0.06
C3	24.69±0.02	14.10±0.022	1.143±0.04	92±0.01	48±0.07	145±0.04
C4	23.42±0.05	12.29±0.009	1.322±0.05	95±0.04	49±0.06	167±0.03
C5	22.85±0.01	13.17±0.017	1.152±0.04	93±0.07	46±0.03	154±0.02
C6	23.01±0.03	14.08±0.014	1.114±0.02	94±0.06	48±0.04	149±0.01
C7	25.76±0.05	15.35±0.024	1.178±0.01	93±0.08	55±0.03	152±0.03
C8	25.42±0.05	14.89±0.009	1.192±0.03	96±0.06	68±0.04	164±0.04

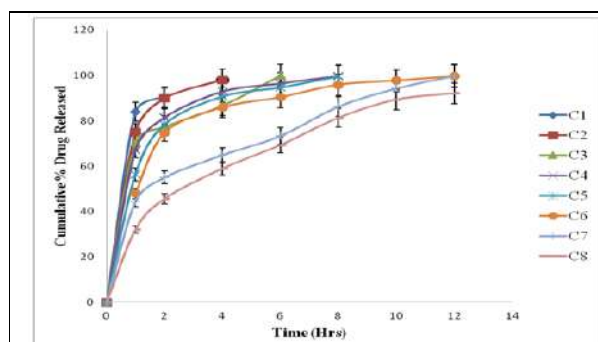




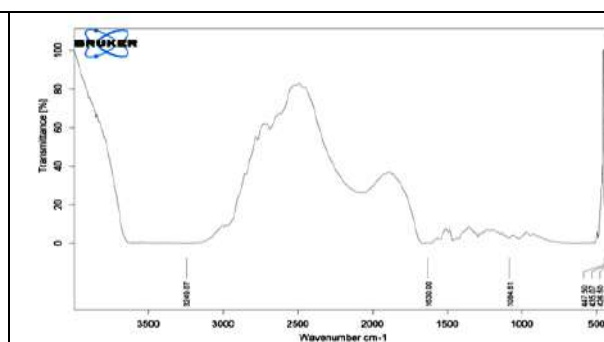
**Table 3: *In vitro* dissolution parameters of Cevimeline HCl controlled release microcapsules**

Formulation	Zero Order		First Order		Higuchi		Peppas	
	K <sub>0</sub> (mg/hr)	R <sup>2</sup>	K <sub>1</sub> (h <sup>-1</sup> )	R <sup>2</sup>	K <sub>H</sub> (mg/h <sup>1/2</sup> )	R <sup>2</sup>	n	R <sup>2</sup>
C1	7.388	0.866	0.274	0.932	38.186	0.942	0.734	0.984
C2	7.094	0.772	0.303	0.954	38.588	0.966	0.518	0.970
C3	7.218	0.861	0.204	0.926	33.634	0.998	0.597	0.943
C4	6.650	0.888	0.325	0.932	32.574	0.911	0.625	0.947
C5	7.054	0.901	0.347	0.956	37.017	0.971	0.784	0.981
C6	6.344	0.904	0.455	0.919	27.888	0.955	0.650	0.987
C7	7.384	0.904	0.455	0.939	26.888	0.945	0.730	0.967
C8	7.984	0.989	0.232	0.986	22.889	0.998	0.877	0.978

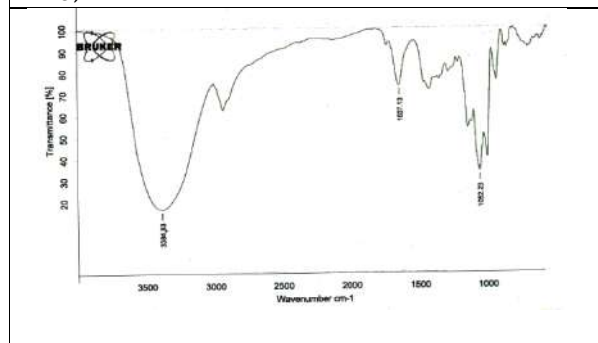
(mean±SD, n = 3)



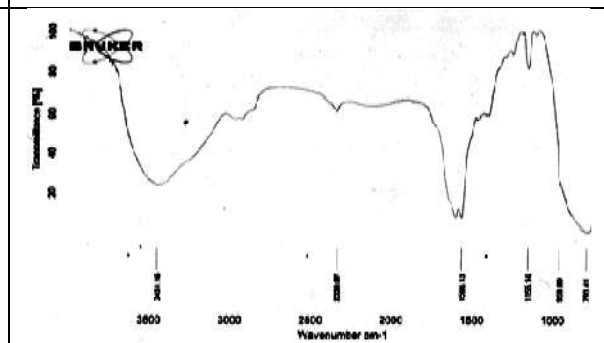
**Fig 1: *In vitro* drug release profiles of Cevimeline HCl controlled release microcapsules (C1 to C8) (mean ± SD, n = 3)**



**Fig 2: FTIR spectrum of Cevimeline HCl pure drug**



**Fig 3: FTIR spectrum of guar gum**



**Fig 4: FTIR spectrum of copal gum**





Balakrishna et al.,

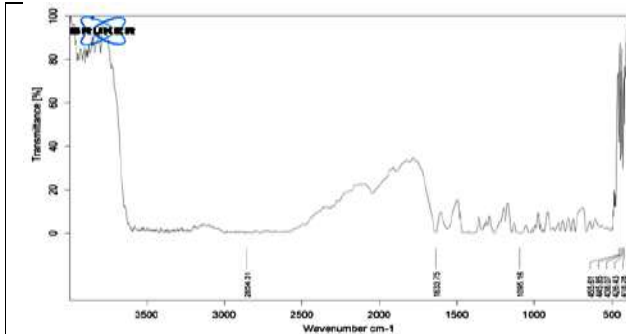


Fig 5: FTIR Spectrum of optimized formulation (C8)

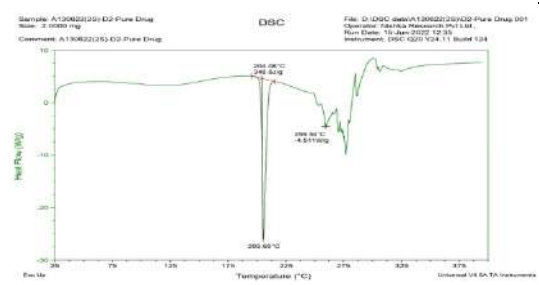


Fig 6: DSC Thermogram of Cevimeline HCl pure drug

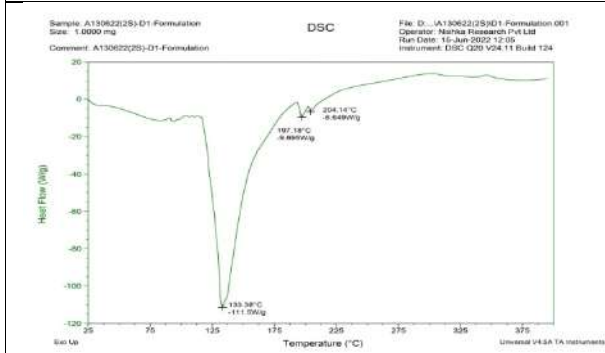


Fig 7: DSC Thermogram of optimized formulation C8

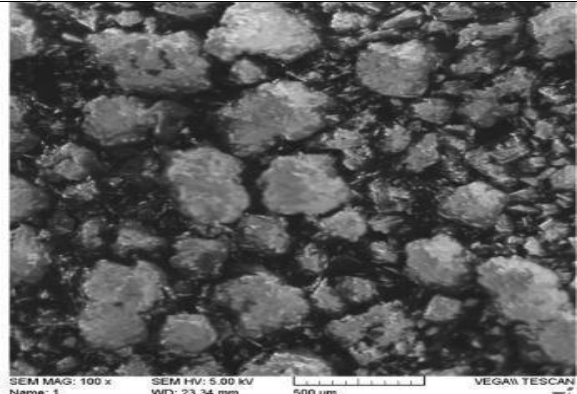


Fig 8: SEM Image of Cevimeline HCl pure drug

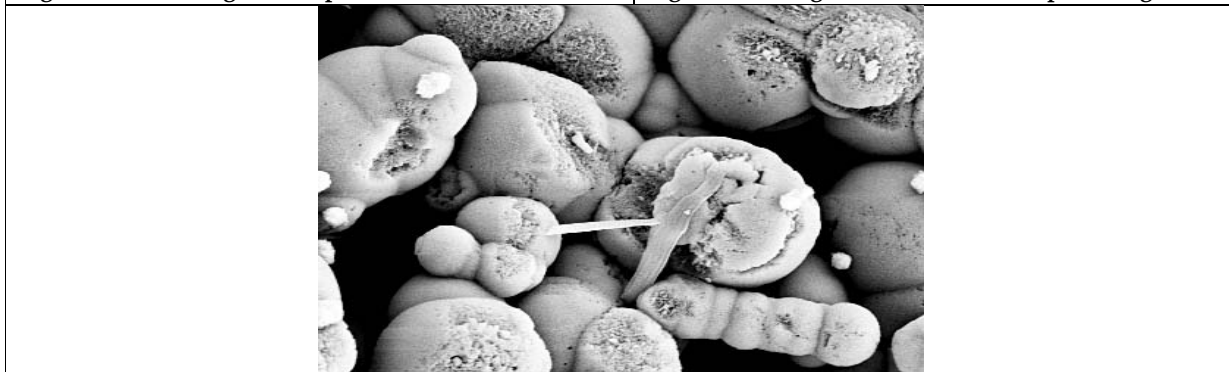


Fig 9: SEM image of optimized formulation (C8)





## One Century of Wolff's Law

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### ABSTRACT

Bone, a highly adaptable tissue, undergoes a constant cycle of growth, modeling during development, and remodeling throughout one's lifetime. The impact of mechanical forces on this process is widely recognized, affecting both the bone's modeling and remodeling phases. The concept of Wolff's Law encapsulates the overall mechanism of how the skeletal tissue adjusts to its functional requirements. Julius Wolff was among the pioneering investigators who sought to delineate the intricate methods through which bone reacts to various mechanical loads. This article undertakes a comprehensive review of Wolff's Law, encompassing its inception, application, and the debates surrounding it.

**Keywords:** Bone, Wolff, mechanical, remodeling

### INTRODUCTION

Recent attention has been directed towards the morphological adjustment of bones in response to their mechanical usage.[1] This interplay between the structure and function of bones prompts inquiries into fundamental







Ravindra Manerikar *et al.*,

physiological mechanisms.[2] Anticipated progress in comprehending how bones adapt to mechanical stress holds the potential for developing targeted approaches to enhance the efficacy and longevity of implanted endoprostheses, as well as refining the therapeutic approaches for distinct bone ailments.[3] The concept that bone structure is influenced by its functional role dates back to the time of Galileo and has been a longstanding observation.[4] In the 1800s, several researchers made noteworthy discoveries regarding the relationship between bone structure and its role. In 1870, Julius Wolff demonstrated that bones altered by disease, upon being reintroduced to their natural functions, adopted the internal architecture typical of healthy bones. This restoration also led to secondary changes wherein the reshaped bones gradually conformed to the standard healthy bone shapes. Subsequently, Wolff conducted further experiments that not only illustrated the ability to induce abnormal bone formations by deliberately disrupting the typical static structure of bones, but also highlighted the potential for reverting the deformed bone shapes to normal by reinstating the original static structure.[5] Wolff's main objective was centered around developing mathematical frameworks that could elucidate the intricacies of bone remodeling, focusing notably on the configuration and alignment of trabecular bone. Evident in his "law of bone remodeling" is the proposition that modifications in the internal structure brought about by primary modeling and subsequent secondary remodeling adhere to mathematical principles. These alterations materialize in response to initial shifts in bone shape and the distribution of stresses applied to the bone.[6]

### The origin of the law

Julius Wolff (Figure 1) emerged as a prominent German anatomist who left a substantial imprint on the scientific sphere during the 19th century. Born in West Prussia in 1836 (present-day Poland), his journey concluded in Berlin in 1902 after suffering from stroke. Having pursued his medical education at Friedrich Wilhelm University, he obtained his degree in 1860 and became one of the pioneering figures in the exploration of orthopedics.[7] Wolff's initial research endeavors centered on the intricate composition of bones. During this period in Zurich, two other scholars, Georg Herman Von Meyer and Karl Culman, were concurrently delving into the architecture and internal makeup of bones.[5] Von Meyer held expertise as an anatomist, while Culman hailed from Switzerland and was trained as an engineer. Notably, Culman devised a methodology that seemingly unveiled the paths of compressive and tensile forces intersecting at right angles within the trabecular structure, as depicted in Figure 2. During a presentation by Von Meyer concerning his bone specimens, Culman observed a remarkable similarity between the angles of trabeculae in these specimens and those present in architectural constructions.[8] Wolff devised a method to examine the trabecular structure within bones during an era when X-ray technology hadn't yet emerged in the late 19th century. In lieu of X-rays, Wolff opted to slice thin sections of bone to delve into their internal arrangements.[9] Wolff's theory posited that the right-angle formations in trabeculae stemmed from the interplay of compressive and tensile stresses. Through a series of papers published in the 1870s, he introduced pivotal concepts that culminated in his seminal work in 1892, titled "The Law of Bone Transformation." In developing his hypothesis, Wolff drew upon insights derived from museum specimens and dissections. This principle, often referred to as Wolff's "law," has also been dubbed the "use it or lose it" law, encapsulating the idea that bones adapt based on their mechanical utilization.[10]

### Wolff's Law

Wolff's proposition suggests that the extent of stress experienced by a bone corresponds to the degree of its morphological transformation, with increased stress leading to reinforcement through deposition.[11] Conversely, in the absence of stress, bones undergo weakening via resorption. Wolff's observations can be distilled into three key points: Within a specific bone type, the arrangement of trabecular architecture consistently follows a uniform pattern across different individuals. Numerous trabeculae intersect at right angles that align with principal stress directions. In instances where a bone suffered deformation or fracture followed by healing, the typical right-angle configuration of trabeculae would be disrupted.[12].

In essence, Wolff's premise asserts that the internal structure of long bones is intricate, characterized by a distinct pattern of right-angle intersections. He concluded that this pattern and orientation of trabeculae undergo alteration







**Ravindra Manerikar et al.,**

due to the interplay of bone deposition and resorption, maintaining a delicate equilibrium dictated by mechanical loads.[13] Ultimately, Wolff deduced that just as trabecular bone constantly evolves, compact cortical bone also undergoes ongoing changes and adaptation. His observations encompassed femora exhibiting healed fractures, wherein the internal trabecular architecture deviated from the norm due to the fracture event. Only the final observation regarding the alteration of trabecular architecture after bone injury was originally introduced by Wolff himself. The initial two observations had been documented earlier, specifically in the late 1850s.[14] In 2010, Richard A. Brand provided a translation of Wolff's fundamental hypothesis, stating, "The law of bone remodeling is that mathematical law according to which observed alterations in the internal architecture and external form of bone occur as a consequence of the change in shape and/or stressing of bone." [7] Brand highlights that while Wolff's "law" is formulated as a mathematical principle, he does not explicitly define the mathematical components involved. Theoretically, when trabeculae are remodeled following injury, the stresses and angles should adhere to the same pre-existing pattern in a specific manner. These anticipated patterns are expected to align with mathematical predictions, although the precise equations remain unspecified.[15]

### **Wolff's Biases**

The "law" proposed by Wolff is associated with three inherent biases, each influencing his formulations in distinct ways. These biases pertain to interstitial bone growth, the role of heredity in bone development, and his conception of function.[11] **Interstitial Bone Growth Bias:** One notable bias in Wolff's thinking was his unwavering belief, almost to the point of fixation, that bone growth paralleled the growth of soft tissues. In his view, this growth process was defined solely by cellular division and the accumulation of intracellular substances. Consequently, he vehemently dismissed the concept of bone resorption, a well-established mechanism of remodeling elucidated by Wegner and Koelliker.[16] For instance, Wegner eloquently explained how the posterior border of the ramus undergoes periosteal apposition while the anterior surface of the coronoid process concurrently experiences resorption, leading to an elongation of the corpus. This viewpoint starkly contrasts with Wolff's notion of an "exclusive mechanism of interstitial bone growth," highlighting their differing perspectives.[17] **Heredity Bias:** Wolff's perception of heredity was shaped by his observation of a unique trabecular pattern in fetal bones unaffected by load-bearing stress. This prompted him to deduce that the observed pattern was likely inherited from one's parents. As his thinking evolved, he gradually revised this claim, exempting bone repair, fractures, and pathological conditions from this inflexible perspective.[13]

### **Function Bias**

Wolff's third bias was centered on his interpretation of the concept of function. His perspective markedly diverged from the modern dynamic understanding associated with actions and activities. Instead, he construed function as fixed prerequisites or constraints, drawing parallels to principles in engineering. His communication frequently drew on comparisons to structures like railway stations, bridges, and ultimately the Eiffel Tower. Through these metaphors, he equated bone with meticulously planned constructions, asserting that trabeculae served a role analogous to iron struts. Wolff steadfastly resisted adopting the idea of remodeling. He maintained that bone's function mirrored that of load-bearing struts, thereby emphasizing the essential requirement for strength in bone's design.[18]

## **REVIEW OF WOLFFIAN LITERATURE**

A comprehensive body of literature surrounds Wolff's law, with numerous reviews exploring supplementary factors that influence the processes of bone formation, remodeling, and healing.

### **Bertram and Swartz on the "Law of Bone Transformation"**

In 1991, Bertram and Swartz conducted a contemporary review of Wolff's "law," delving into its foundations based on prevailing evidence. Their study encompassed four pivotal dimensions essential for grasping Wolff's "law": the trajectorial theory, bone atrophy, hypertrophy, and the processes of generation and regeneration (Bertram and Swartz, 1991). They meticulously examined the intricacies of bone remodeling, considering both inherent and external factors, such as hormonal influences, the age of bone, the site of remodeling, and distinctions between non-



**Ravindra Manerikar et al.,**

surgical and surgical experiments, among others. While acknowledging that mechanical loading does exert an impact on bone formation during development, these researchers found scant proof for its influence on fully developed bone.[19]

**Ruff Review of Wolff's "Law"**

In a contemporary evaluation of Wolff's "law" in the 21st century, Ruff and colleagues address prevailing misconceptions associated with this principle. Their analysis serves to differentiate between the broader concept of Wolff's "law" and its mathematical rendition (2006). This broader concept, which Ruff et al. propose as functional bone adaptation, underscores the impact of mechanical loading on bone morphology (Ruff et al., 2006). However, the researchers raise several critiques concerning experimental data exploring Wolff's concepts. They highlight the challenge of discerning between pathological and normal bone responses, a distinction that proves intricate (Ruff et al., 2006). Furthermore, Ruff et al. draw attention to the distinction between stress and strain applied to bone. Strain denotes the physical deformation or reconfiguration of bone tissue, whereas stress entails the imposition of force or load per unit cross-sectional area of bone (Ruff et al., 2006; Bertram and Swartz, 1991) [19,20]. Stress, manifested through loading, compression, and lateral bending, also prompts augmented bone deposition beneath the periosteum. Substantial experimental data substantiate functional bone adaptation in growing bones, but limited evidence supports the same phenomenon in mature bones. The characteristics of mature bone reflect previous mechanical loading experienced during childhood and genetic influences, contributing to the challenge of exclusively attributing bone functional adaptation to a specific period of mechanical loading. Consequently, Wolff's "law" is less well-explored in the context of mature bone[20].

**Studies on bone morphology**

In 2003, a team of researchers from Kent State University embarked on a study that offers insights into bone morphology and challenges Wolff's "law." Their investigation centered on a range of femurs and humeri, encompassing infant to adult stages, to unravel genetic influences on bone structure. This study refutes the conventional understanding encapsulated in Wolff's "law." The researchers conducted two distinct studies, involving long bones from the Libben site and the Hamann-Todd collection at the Cleveland Museum of Natural History. In the first experiment conducted in 2002, the researchers focused on the crucial gluteal insertion within the femurs of both populations. Notably, they found that the Libben collection, representative of an American Indian population from northern Ohio, exhibited greater rugosity compared to the Hamann-Todd collection. To delve deeper, the team carried out a subsequent study aimed at exploring the strain history within the deltoid insertion site of the corresponding humeri. If the observed rugosity were indeed attributed to mechanical loading and activity levels, the findings should mirror similar changes in this distinct insertion site. Serrat et al. casted 22 Hamann-Todd and 28 Libben humeri ranging from infancy to sub-adulthood in 2003. The process involved ranking the rugosity of the deltoid tuberosity, which serves as the insertion site for the deltoid muscle. Additionally, bone length was considered as an indicator of bone age. By assessing whether there exists a positive correlation between the rank order of rugosity and bone length (age), the researchers aimed to ascertain if the observed differences in rugosity between populations could indeed be attributed to mechanical strain. To quantify rugosity, the humeri casts were assigned random numbers, and three independent observers conducted seriation based on the size and surface characteristics of the deltoid tuberosity.[21]

**DISCUSSION**

The current review highlights the necessity for a reevaluation of the foundational tenets underpinning Wolff's "law." It becomes evident that Wolff's assertion of bone's self-remodeling under mechanical loads does not universally apply. Importantly, Wolff's core principle concerning trabecular pattern remodeling primarily finds validation in the context of fracture remodeling. This indicates a departure from supporting the trajectorial theory (Bertram and Swartz, 1991)[19]. When considering long bones, the augmentation of bone with increased loading is a phenomenon confined to growing bone, as mature bone ceases to experience such changes due to the inactivation of growth



**Ravindra Manerikar et al.,**

plates[22]. A significant portion of the literature advocating Wolff's "law" centers around sub-adult bones, with limited experimental backing for Wolff's propositions pertaining to mature bone. However, research related to spaceflight-induced atrophy does align with Wolff's law in mature bone (Bertram and Swartz, 1991; Amin, 2010)[19,23]. The extant experimental studies are not uniformly controlled to effectively eliminate intrinsic factors, particularly genetic components (Ruff et al., 2006)[20]. The significance of infant and juvenile skeletal investigations underscores the pronounced role of genetics in bone development. Analysis of infant and neonatal pelvises unveils the influence of genetic patterning on future load-bearing patterns[24]. This influence is attributed to cis-regulatory elements governing gene expression throughout one's lifespan, contributing to phenotypic variation. This phenomenon was evident in the Kent State University studies by Serrat et al. (2003), where distinctive differences were noted in the rugosity of gluteal tuberosities between the Libben and Hamann-Todd populations. These findings also align with the variations observed in deltoid insertions within the two populations[21]. Wolff's "law" continues to find prominence in the education and practices of researchers, anatomists, and bioarchaeologists, persisting as a notable concept in bone studies [25]. The realm of bone morphology is inherently intricate, encompassing multifaceted mechanisms such as cell signaling and chemical interactions that underpin bone remodeling, elements that remain subjects of ongoing debate and ambiguity [26]. As the domain of osteology undergoes continued development, a more coherent understanding of the intricate interplay between these pathways is anticipated to take shape [27].

## CONCLUSION

A century after Wolff's original publication of "The Law of Bone Remodeling," his ideas continue to endure the test of time. Wolff's postulation has gained recognition as an accepted phenomenon. However, a substantial body of research spanning the years has emerged, challenging the law's status and proposing that it should be regarded more as a hypothesis rather than an absolute law.

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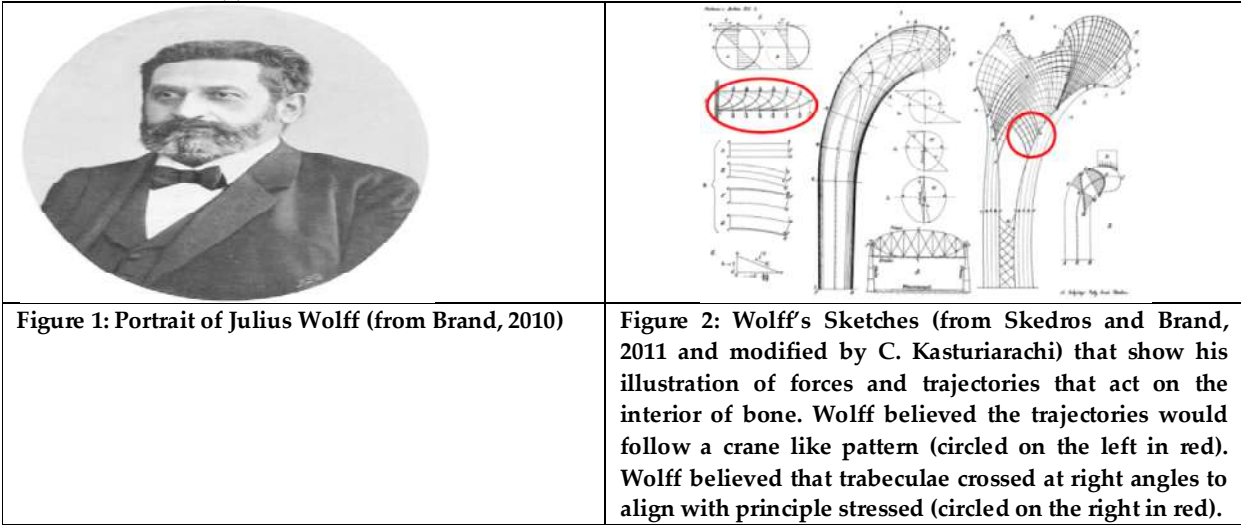
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## Effectiveness of Pilates on Core Endurance among College Level Cricket Player

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### ABSTRACT

Poor physical components lead to many injuries during the game. Core is the powerhouse of the body. Training to enhance core endurance improves the strength of trunk muscles and allows the players to kick, throw, pull, and push with greater force. There are several ways to strengthen the core muscles by training programs. Pilates workout focuses on enhancing strength, flexibility, core stability, control of trunk and pelvic segments, posture and breathing. Total 30 cricket players participated in this study according to selection criteria from Parul University, Vadodara. Pilates training given to the participants for 3 sessions/week for 6 weeks. Core endurance measured by plank test before and after intervention. Data analysis done by paired t test using SPSS version 20. Pilates training effectively improves core endurance in college level cricket players.

**Keywords:** Pilate, core endurance, cricket players

## INTRODUCTION

Cricket is the most played game in India and across the world. With the time passed, cricket become more popular and highly watched game by the peoples. So, every player need to get their excellence to do well in their game and make a place for own self in the area of so much competition. Physical fitness is first very important thing for better performance[1] Numerous accidents during the game are caused by poor muscle components. Back complaints frequently correlated with shoulder droop, horizontal bending strength for the desired limb, and quadriceps power in the unwanted limb.[2]Back injuries were more likely to occur in bowlers who turned their bodies to reposition their shoulders more side-on during the delivery stance more than 40 °. Cricketers are 14–18% more likely to sustain trunk and spinal injuries. Lower limb accidents recorded between 25% - 30% of the time.[3] Because of the higher physical requirements of the game, where players must handle the field, bat, and hit the ball at all times, the risk of harm may rise. Athletes need powerful core muscles and stamina to prevent this problems.[4]Cricket players need to





**Sandip Parekh and Kishita Davariya**

have strong core muscles; the core is a vital connection between the upper and lower extremities. Therefore, it is crucial to protect players from lower limb and low back problems.[5] Thus, literature shows that to perform better in this high competition and to reduce the risk of injuries, player need to be their excellence. Strength, power, agility, speed, endurance are components to determines the fitness. Playing performance determined by a variety of variables working together. One of these elements is the physical endurance necessary for successful hitting, bowling, and catching.[1] Professional athletes must undergo the proper therapy to speed up their return to function because their core stability requirements for sport performance are much higher than those for everyday activities. These meanings indicate that in order to enhance performance and encourage effective biomechanics, core stability in sports requires actively regulating and distributing significant forces from the upper and lower limbs through the core.[6] In order to properly generate transfer and control of force and motion to the terminal section during integrated synchronized sports activities, one must be able to control the position and movement of the torso over the pelvis, This defined as core stability.[3] In all kinds of sports, from sprinting to tossing, core stability is seen as being crucial for effective biomechanical function to optimize force production and reduce joint burdens. The center of the body's strength is its core. The players can kick, throw, drag, and press harder owing to improved trunk muscular power from core conditioning.[7] There are several ways to strengthen the core muscles such as medicine balls, stability balls, balance board, yoga, conventional resistance exercises, Pilates and other exercises, such as swimming. Also bands, and pulleys have been some of the approaches to train the core.[4]

Joseph Pilates created the Pilates method in the 1920s. As implied by its initial term, "Contrology," a focus is put on control of bodily motion and positioning. Trainings are ground based, or involve the use of specialized tools that give adjustable spring resistance. The traditional Pilates workout principals include breathing, centering, attention, control, and accuracy. These principles defined in Table 1. Power, flexibility, abdominal stability, control of the trunk and pelvic regions, balance, and respiration are the main goals. These advantages have made it famous among people who have lower limb and spinal injuries. Daily Pilates practice has been shown to greatly reduce the severity of low back pain by strengthening isometric trunk extension and flexion and engaging the deep muscles that support the lumbar-pelvic region.[9,10] Pilates' fundamental principles of control and focus increase an athlete's awareness of how their mind affects their physical action. To achieve at their highest level, an athlete needs a powerful, flexible, and unrestricted core.[4] This pilot study aimed to determine the effects of Pilate training on core endurance in college level cricket players.

## MATERIALS AND METHOD

### SOURCE OF DATA

Parul university campus, At Po: Limda, Ta: Waghodia, Dist.: Vadodara.

### METHOD OF COLLECTION OF DATA

1. Study design: a pilot study
2. Sampling method: randomized control method
3. Study duration: 1 years
4. Data collection duration: 6 months
5. Sample size: 30 patients
6. Training duration: 6 weeks (3 sessions/week)

## MATERIAL USED

Consent form, Pen, Pencil, Mat, Laptop, Con for markers

### INCLUSION CRITERIA

1. Subjects those who are willing to participate and sign consent form.
2. Age: 18 - 30 years.
3. Males and females both included.





**Sandip Parekh and Kishita Davariya**

- Subjects should be participated at least in one college cricket tournament.

**EXCLUSION CRITERIA**

Subjects with neuromuscular condition, any spinal injury, injuries on lower limb, musculoskeletal injury and amputation. Athletes with injuries, trauma, and pathology, any neurological or psychological complications and athlete with recent change in sports.

**OUTCOME MEASURE** plank test

**TRAINING PROTOCOL** Training duration: 3 sessions/week for 6 weeks

Warm up – breathing, the hundred, arm circles (each exercise done for 8 repetitions)

Exercise – one leg circle, double straight leg stretch, plank, spine twist, teaser, push up (each exercise done for 8 repetitions)

Cool down – 3 rep each muscle(30 sec hold)Stretching (triceps, biceps, quadriceps, hamstring, glutei, calf, quadratus lumborum, child pose and cobra pose)

**RESULT**

Data was analyzed by SPSS software version 20.0 and Microsoft Excel 2010. Prior to the statistical test, data was screened for normal distribution by Shapiro-Wilk test. After normal distribution of the data, paired t test was applied at 0.05 level of significance with 95% of confidence interval. Table 3.1 and Graph 3.1 showed the pre and post difference of intervention mean of plank test for Group A. Data analysis was done using paired t-test, pre-test MEAN±SD value was 82.03±16.464, post-test MEAN±SD was 109.50±16.464. There was major difference post intervention in plank test which showed improvement in core endurance of Group-A. P value found out to be 0.000 with  $P < 0.05$ , which is considered significant.

**DISCUSSION**

Each athlete should prioritize the development of particular physical attributes since they are necessary for any physically demanding activity or sport. Key physical qualities needed for success in cricket are speed, agility, power, and endurance. Cricket requires a variety of skills like running, catching, jumping, fielding, batting and bowling etc. speed is one of most important component to succeed in today's competition. Pilates exercise is very effective to improve physical attributes. The traditional Pilates workout concepts include breathing, centering, attention, control, and accuracy. 30 cricket players of Parul University were the subject of the current study. Plank test was used to pre and post evaluation. Training were given to subjects for 3 sessions / week for 6 weeks. One study conducted by Sohail, Khalid, Mumtaz, Qadri, Shah in 2021 entitled as study on "Effects of pilate training on physical performance of cricketers". Randomized control experiment undertaken from June 2020 to March 2021 at LFR 18Active Gym 18, Islamabad. The research included active male cricketers aged 19 to 30 who had played for at least two years and had normal BMIs. The n=20 individuals were selected using a non-probability convenient sampling procedure and divided into two groups if they met the inclusion requirements. Pilate training and a conventional training exercise program given to the experimental group. The control group, however, simply got the conventional training. Before and after the intervention, the 30-foot agility shuttle run test, the endurance test, the underarm throw accuracy test, the throw-length test, and the ground fielding test were all conducted. To observe the differences within groups while adjusting for confounding factors, the MANCOVA was used. It was proven that combining Pilates with traditional training considerably enhanced cricketers' physical performance. Discussing about core endurance for Pilates group measured by using plank test is shown in Table 3.1 and graphically illustrated through Graph 3.1, where the mean value post intervention increased to 109.50 from 82.03. Result shows that pilates is very effective for core endurance.





**Sandip Parekh and Kishita Davariya**

**CONCLUSION**

The current study aimed to check the effectiveness of Pilate training on endurance among college level cricket players. Based on analysis and result it was concluded that, pilates is very effective for improving core endurance.

**LIMITATIONS**

1. The research used a tiny sample size.
2. The intervention duration of the study was small.

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TRADITIONAL PRINCIPLE	DEFINITION
Centering	Exercise-induced tightening of the muscles in the "powerhouse," the region of the body in between pelvic region and the ribs.
Concentration	To practice properly, one must pay focus cognitively.
Control	controlling alignment and action carefully while working out
Precision	Accuracy of each exercise method
Flow	Smooth transition of movements within the exercise sequence



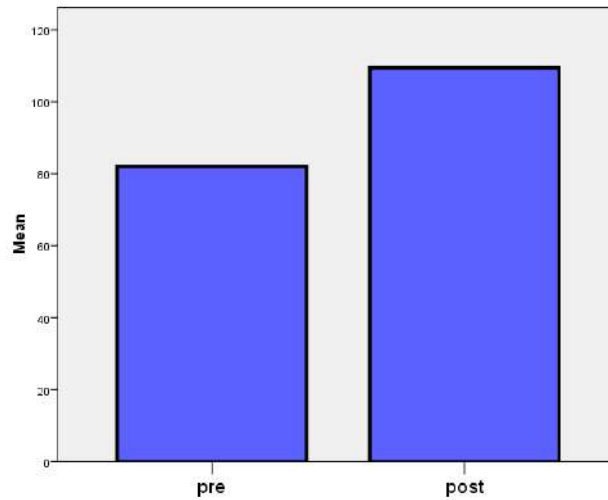


**Sandip Parekh and Kishita Davariya**

Breathing	Moving air into and out of lungs in coordination with exercise
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**TABLE: 3.1 PRE-POST COMPARISON OF PLANK TEST**

MEAN	MEAN	±SD	T VALUE	DF	P-VALUE
PRE	82.03	16.464	-37.878	29	0.000
POST	109.50	16.940			



**GRAPH: 1 PRE-POST COMPARISON OF PLANK TEST**





## An Astonishing Contemplation on Pitha Sura Kudineer to Modulate Pitha Suram

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### ABSTRACT

Siddha system of medicine is a folk care medicine, founded by Siddhars before an era. The Siddhars were further greatest scientist in ancient times. They were men of highly cultured intellectual and spiritual faculties combined with supernatural powers. Their work in Tamil is more profitable than many that have been write down in Sanskrit. They contain a large number of valuable formulae and exhibit further minute enumerations of morbid symptoms. They evince a moral conviction of the intervention of the evil spirits and offer many curious rules averting their evil influences and effects. The Siddha system includes vatham, vaithiyam and yogam. Vaithiyam includes 32 internal medicine and 32 external medicines. Among various internal medications, kudineer (decoction) is a fast action medicine which absorbs via ptyalin. Fever is a common medical sign. It is also mentioned as pyrexia, is defined as having a temperature greater than the normal range due to an rise in the body's temperature nominal value. *Kannusamy pillai's Chikicha rathna deepam's Pitha sura kudineer* is a Herbal preparation helps in dwindling pitha suram[1]. This paper gives a brief summary about Pitha Sura Kudineer preparation and various pharmacological aspects.

**Keywords:** *Kannusamy pillai, Chikicha rathna deepam, Pitha sura kudineer, siddha medicine.*





## INTRODUCTION

Siddha system of medicine is a explorer of traditional healing system. Siddha maruthuvam means “siddh” defines “arivu” (Knowledge). “Siddham” defines “Manam”. The siddhars are those who have reached the supreme shiva with the aid of knowledge of the wandering mind and they have blessed in siddha medicine. The famous siddhar Yugi in his quote says diseases as 4448. One among them is suram which makeover a pandemic threatened in the world for 2 years. According to saint Theraiyar, Suram is classified into 64 types. Among them vatham comprises of 20 types, pitham is of 24 types and kabam is of 20 types. As per saint Theraiyar’s phrase “pinimuthar karanam” (Etiology) of fever is “kudalthannil seethamalathu suram varathu”. Now a day it speaks decreased gut health is the main cause for fever. Siddha medicine has various modes of internal administration. Kudineer (decoction) helps in strengthening gut microbes which reduce seetham (coldness) in stomach. Pitha Suram comes under vitiated pitham humour, pitha suram upsets everyone just as the demon’s torment anyone’s mind with their powerful magic tricks. Symptoms of pitha suram includes

- ❖ mood swings, confusion, body tremors,
- ❖ redness of the body,
- ❖ drooling in the mouth,
- ❖ debilitation, fatigue,
- ❖ redness of eye,
- ❖ stuffering and slurred speech,
- ❖ diarrhoea,
- ❖ hyper pigmented face,
- ❖ increased thirst,
- ❖ hiccups, sleep disturbance,
- ❖ bloating abdomen,
- ❖ vomiting, dryness of mouth,
- ❖ dark yellowish micturation
- ❖ throat ulcer and
- ❖ continuous fever[2]

This paper brings the brief explanation about preparation of pitha sura kudineer and its various phytochemical, nutritional values and pharmacological actions.

### INGREDIENTS OF PITHA SURA KUDINEER

1. PEIPUDAL (*Trichosanthes lobata.Linn*)
2. KIRAMBU (*Syzygium aromaticum.Linn*)
3. CHUKKU (*Zingiber officinale.Linn*)
4. KORAI KIZHANGU (*Cyperus rotundus.Linn*)
5. NILAVEMBU (*Andrographis paniculata.Linn*)
6. KOTHTHUMALLI (*Coriandrum sativum.Linn*)

### PREPARATION OF PITHA SURA KUDINEER

Kaattu peipudal / Snake gourd, Lavangam / Cloves, clove tree, Chukku / Dried ginger, Korai / Nut grass, Nilavembu / Green chiretta kalmegh, creat, Koththumalli / Coriander seeds add each herbs one thola (11.6gm), add ½ padi (350 ml) water soak the above ingredients for two hours and boiled it to ½ aalakku (47ml), have it for three days to get rid from pitha suram[1].





Hema et al.,

**PHYTOCONSTITUENTS AND NUTRITIONAL VALUES OF PITHA SURA KUDINEER****PEIPUDAL (*Trichosanthes lobata*)**

Aghil Soorya Aravindakshan et al., studied that *Trichosanthes lobata* contains potassium hydroxide, ferric chloride, sodium hydroxide, hydrochloric acid, glacial acetic acid, nitric acid, and sulfuric acid. It also has foreign matter, ash, soluble solids, moisture, crude fat, and fiber contents. The leaves contains carbohydrate (27.32 mg GU eq./g), starch (32.44 mg GU eq./g), protein (52.49 mg bovine serum albumin eq./g), amino acid (33.77 mg LE eq./g), Vitamin C (12.68 mg ascorbic acid equivalent eq./g), and Vitamin E (8.21 mg  $\alpha$ -TOP eq./g). The minerals present in magnesium, potassium, calcium, sodium, lithium, iron, zinc, aluminum, copper, nickel, and chromium[4].

**KIRAMBU (*Syzygium aromaticum*)**

Monika Mittal et al., reported that the Clove bud contain 15-20% essential oil which is dominated by eugenol (70-80%), eugenyl acetate (15%) and  $\beta$ -caryophyllene (5-12%). The other important ingredients found in clove oil are vanillin, maslinic acid, kaemferol, rhamnnetin, eugenitin, eugenin, gallic acid, biflorin, myricetin, campesterol, stigmasterol, oleonolic acid, bicorin [5].

**CHUKKU (Dried Rhizome OF *Zingiber officinale*)**

D.M.A.Jeyaweera et al., reported that dried rhizome of ginger contains Gingerol, Shogol, Zingerone, Gingerine, Gingeberol, Essential oil-Camphene, phellandrene, cineol, zingiberene and borneol, resin and starch<sup>[6]</sup>.

**KORAI KIZHANGU (*Cyperus rotundus*)**

Previous studies showed that *Cyperus rotundus* contains phytoconstituents such as alkaloids, flavonoids, phenols and glycosides. Alkaloids include atropine (0.78 g/100 g), quinine (0.04 g/100 g), and vincristine (0.04 g/100 g), quinidine (0.001 g/100 g) and ricinine(0.003/100 g). Flavonoids (38.68g /100g), epigallocatechin (11.03 g/100 g) and tangeretin (0.31 g/100 g). Glycosides include digoxin acid (8.16 g/100 g), lisinopril acid (0.001 g/100 mg), propranolol acid (0.001 g/100 mg), cinnamic acid(0.07 g/100 g), gentiic acid (0.18 g/100 g), and piperonic acid (0.02 g/100 g). The vitamins present are Vit. A 15.02%, Vit. B3 0.05%, Vit. B6 1.00%, Vit B1 1.00%, Vit. B2 0.97%, Vit.B12 3.00% and Vit. E 0.03%. It also contains carbohydrates, tannins, saponins, anthrocyanin, betacyanin, quinones, terpenoids, coumarins, proteins, steroids and phytosteroids<sup>[7,8]</sup>.

**NILAVEMBU (*Andrographis paniculata*)**

In ethanolic aqueous extract leaves of *Andrographis paniculata* contains saponin, tannin, phenolic compound, flavonoids and alkaloids. In methanolic and acetone aqueous extract it contains saponin, tannin, flavonoids and alkaloids. The leaves of *Andrographis paniculata* have the following nutrients: Moisture (8.22g /100g), ash (15.66g / 100g), fat (0.9g / 100g), protein (10.3g /100g), carbohydrate (64.8g /100g), vitamin C (59.5mg / 100g), crude fiber (12.7g / 100g). The macro elements present are magnesium (243.4mg / 100g), calcium (857.4mg / 100g), potassium (1062.6mg / 100g), phosphorus (346.9mg / 100g), sodium (0.2mg / 100g). The micro elements present in leaves of *Andrographis paniculata* are iron (491.4mg /100g), zinc (1.3mg / 100g) and manganese (1.6mg / 100g)<sup>[9]</sup>.

**KOTHTHUMALLI (*Coriandrum sativum*)**

Peter et al., reported that coriander seeds contains starch (11g / 100g), fat (20g / 100g), protein (11g / 100g), and crude fiber (30g / 100g). It also contains water (11.37%), crude protein (11.49%), fat (19.15%), crude fiber (28.43%), starch (10.53%), pentosans (10.29%), sugars (1.92%), mineral constituents (4.98%) and essential oil (0.84%). Essential oils, fatty acids, carotenoids, isocoumarins, alkaloids, flavones, resins, tannins, anthraquinones, sterols, fixed oil, polyphenols, vitamins and many phytosterols are also present. The nutrients present are vitamin A/ $\beta$ -carotene: 12 mg/100 g and vitamin C: 160 mg/100 g, iron, thiamine, zinc and dietary fiber<sup>[10,11,12,13]</sup>.

**PHARMACOLOGICAL ACTIVITIES OF PITHA SURA KUDINEER****PEIPUDAL (*Trichosanthes lobata*)**

*Trichosanthes lobata* exhibit various pharmacological activities such as antimicrobial, antioxidant, anticancer, anti-inflammatory, anti-obesity, anti-angiogenic, neuroprotective and hepatoprotective activities etc<sup>[4]</sup>.





**Hema et al.,****ANTI-INFLAMMATORY ACTIVITY**

Previous studies shows that the ethyl acetate and methanol extracts of leaves of *trichosanthes lobata* exhibit a potent anti-inflammatory activity[4].

**HEPATOPROTECTIVE ACTIVITY**

Aiyalu Rajasekaran et al., reported that the ethanolic extract of *Trichosanthes lobata* possess protective activities against paracetamol-induced hepatotoxicity. The study of serum markers such as AST, ALT, ALP, bilirubin and total protein were reduced to normal levels [14].

**KIRAMBU (*Syzygium aromaticum*)****ANTIBACTERIAL ACTIVITY**

Demirpek et al, reported that aqueous and ethanolic extracts of clove buds inhibit growth of methicillin resistant clinical isolates at 1000 and 500mg/ml concentration [15].

**ANTIFUNGAL ACTIVITY**

Devi et al., reported that In chromatographic analysis eugenol was found to be the main compound responsible for the antifungal activity, due to lysis of the spores and micelles. A similar mechanism of action of membrane disruption and deformation of macromolecules produced by eugenol<sup>[16]</sup>.

**ANTIOXIDANT ACTIVITY**

Dorman HJD et al, studied that clove essential oil has the highest antioxidant capability and perhaps one of the best known oil for food or supplement. For this reason, it has been included in some longevity formulae. The results concluded that clove and eugenol possess strong antioxidant activity, which is comparable to the activities of the synthetic antioxidants, BHA and pyrogallol[17].

**ANTICARCINOGENIC ACTIVITY**

Schonfelder I et al suggested that chemo preventive role of clove oil, particularly in cases of lung, skin and digestive cancers [18].

**ANTI-INFLAMMATORY ACTIVITY**

Ozturk A et al., in his studies showed that the essential oil possess significant anti-inflammatory effect at doses of 0.05 ml/kg (90.15% inhibition) and 0.200 ml/kg (82.78%) inhibition [19].

**ANALGESIC ACTIVITY**

Hosseini M et al., documented that eugenol's anaesthetic effect helps in dental pain as well as analgesic and anti-inflammatory effects in animal models[20].

**ANTITHROMBOTIC ACTIVITY**

Srivastava KC et al., investigated that eugenol and acetyl eugenol are found to be more potent than aspirin in inhibiting platelet aggregation induced by arachidonate, adrenaline and collagen [21].

**ANAESTHETIC ACTIVITY**

Hamackova J et al., reported that clove oil and eugenol act as an acceptable anesthetic for rabbit fish (*Saiganus lineatus*), coral reef fish (*Pomacentrus amboinensis*) and rainbow trout (*Oncorhynchus mykiss*) for use in aquaculture and aquatic research [22].

**ANTIPYRETIC ACTIVITY**

Feng J et al., exhibited antipyretic activity when given intravenously and intragastrically and may decrease fever through a central action that is similar to that of allopathic antipyretic drugs such as acetaminophen [23].



**Hema et al.,****CHUKKU (*Zingiber officinale*)**

The pharmacology action of dried ginger is carminative, stomachic, circulatory stimulant, diaphoretic, digestive, antispasmodic, anti-emetic, expectorant, rubefacient and sialagogue [6,24,25,26].

**KORAI KIZHANGU (*Cyperus rotundus*)****ANTI-PYRETIC ACTIVITY**

Gupta MB et al., studied that the alcoholic extract of *C. rotundus* showed highly significant ( $P < 0.001$ ) antipyretic activity against pyrexia produced in albino rats by the subcutaneous injection of suspension of dried Brewer's yeast in gum acacia in normal saline. A specific fraction obtained by chromatographic method from the petroleum ether extract was found to possess a significant anti-pyretic effect similar to acetyl salicylic acid when used on the same animal model [27].

**ANTIMICROBIAL ACTIVITY**

Singh et al., investigated that Antimicrobial activity tests were carried out on human pathogens bacteria (gram negative and gram positive) and fungi viz. *C. albicans* and *A. niger*. The highest percentage of inhibition was observed against *K. pneumoniae* (133.33%). Amoxicillin 20 µg/ml and ethanol (as fungicide) 70% were used as positive control. Moderate inhibition was observed in case of *A. niger* and *S. aureus* (90 and 70% respectively). No zone of inhibition was observed in Acinto bacter and Candida [28].

**ANTIBACTERIAL ACTIVITY**

Chandratre R. S et al., and Kilani S et al., in their study observed that a marked inhibitory effect of *C. rotundus* against *Salmonella enteritidis*, *Staphylococcus aureus* and *Enterococcus faecalis* with total oligomers flavonoids (TOFs) and ethyl acetate extracts<sup>[29,30]</sup>.

**ANTIMALARIAL ACTIVITY**

Thebtaranonth C et al., studied that sesquiterpenes *C. rotundus* rhizomes showed in-vitro antimalarial activity against *Plasmodium falciparum* [31].

**ANTI INFLAMMATORY ACTIVITY**

Sundaram, M.S. et al., reported that the alcoholic extract (70% alcohol) possessed anti inflammatory activity against carrageenan induced oedema and also found effective against formaldehyde induced arthritis in albino rats [32].

**ANALGESIC ACTIVITY**

Gupta MB et al., and Birdar S et al., reported that the petroleum ether extract and essential oil of *C. rotundus* are possess analgesic activity [27, 33].

**TRANQUILIZING ACTIVITY**

Singh N et al., showed that the ethanolic extract of *C. rotundus* potent tranquilizing activity in various tests: reduced the spontaneous motor activity, potentiated the pentobarbital narcosis and deranged the motor coordination, abolished the conditioned avoidance response in animals [34].

**ANTICONVULSANT ACTIVITY**

Pal D et al., studied that pretreatment with ethanolic extract of *C. rotundus* caused significant protection against strychnine and leptazol-induced convulsions in mice [35].

**ANTI-EMETIC ACTIVITY**

Singh N et al., investigated that the ethanolic extract of *C. rotundus* in the dose of  $128.1 \pm 11.6$  mg/kg was found to protect 50% dogs against apomorphine induced vomiting [34].



**Hema et al.,****ANTISPASTIC ACTIVITY**

Singh N et al., reported that the ethanolic extract of *C. rotundus* produced relaxation of rabbit ileum and spasmolytic effect against contractions induced by acetylcholine, barium chloride and 5-hydroxytryptamine, showing a direct relaxant action on the smooth muscle [34].

**GASTROPROTECTIVE ACTIVITY**

Santhosh Kumari et al., showed that the *C. rotundus* extract protected against gastric mucosal injury induced by ischemia and reperfusion in rats. The mean ulcer index of rats treated with 200 and 100 mg/kg *C. rotundus* were significantly lower than that of control. The activities of glutathione-peroxidase and malondialdehyde were significantly affected by treatment of *C. rotundus* [36].

**HAEMODYNAMIC (HYPOTENSIVE) ACTIVITY**

Singh N et al., studied the alcoholic extract of *C. rotundus* produced gradual and persistent fall in blood pressure and stimulated the respiration. The responses of epinephrine and acetylcholine on blood pressure were not altered by the extract, but that of histamine was partially blocked [34].

**HYPOLIPIDEMIC ACTIVITY**

Nagulendran K R et al., *C. rotundus* extract restored the age associated change in serum lipids (total cholesterol, LDL cholesterol, DL cholesterol, triglycerides and VLDL triglyceride level) to the level of young control rats. In young rats, treatment of *C. rotundus* significantly increased HDL cholesterol level [37].

**ANTI-OBESITY ACTIVITY**

Bambhole V D et al., studied that the *C. rotundus* preparations (powder in fine suspension, aqueous and alcoholic extracts) exhibited a lipolytic action and mobilized fat from the adipose tissues in rats, thus helping to reduce the obesity [38].

**ANTICANCER ACTIVITY**

Kilani S et al., showed that *C. rotundus* essential oil was very effective against L1210 leukaemia cells line. This result correlated with significantly increased apoptotic DNA fragmentation [39].

**NILAVEMBU (*Andrographis paniculata*)****IMMUNOLOGICAL POTENTIAL**

Bharati et al., studied the extract of *A. paniculata*. *Andrographis paniculata* was proposed as a potent stimulator of immune system by two approaches. First was an antigen specific response; in which antibodies were made to counteract invading microbes and the second was a nonspecific immune response; macrophage cells scavenged and destroyed invaders. Since *Andrographis paniculata* activated both responses, it may be effective against a variety of infectious and oncogenic agents [40].

**ANTIMALARIAL ACTIVITY**

Rehman NN et al., studied that *A. paniculata* extracts effectively killed filarial that obstruct lymph channels consequently leading to elephantiasis, in dog. Recent research also reported Antimalarial effect of *A. paniculata* against Plasmodium falciparum [41].

**ANTICANCER POTENTIAL OF ANDROGRAPHOLIDE**

Vojdani A et al., showed that andrographolide presents a strong candidature as a therapeutic anticancer Pharmacophore as it exhibits a dual property, acting both directly and indirectly on the cancer cells [42].

**CYTOTOXICITY AGAINST CANCER CELLS**

Siripong P et al., studied that the methanolic extract of *A. paniculata* had shown noteworthy toxicity against human epidermoid leukemia and lymphocytic leukemia cell lines [43].



**Hema et al.,****CARDIOVASCULAR ACTIVITY**

Huang L Y et al., investigated that the arterial narrowing caused by injury to the inner lining of the blood vessels and by high cholesterol in the diet was also found to be reduced by the plant *A. paniculata*. On the relaxation of the smooth muscle wall of the blood vessels, Andrographis additionally showed antihypertensive effects by consequently resulting in lowering of blood pressure in nor adrenaline-treated rats [44].

**ANTI-FERTILITY ACTIVITY**

Janarathanan S et al., recommended anti-fertility effect in andrographolide with changes in the biochemical parameters in rats, such as significant decreases in protein content, but marked increases in cholesterol, acid phosphatase, and alkaline phosphatase levels with appearance of fructose in the reproductive system[45].

**ANTIVENOM ACTIVITY**

Samy RP et al., showed that the oral administration of Plant extracts of *A. paniculata* (7.2 mg/kg body weight) and particularly purified fractions (2.4 mg/kg body weight) to mice experimentally envenomed with rattle snake venom s. c. injection (2.5-15 mg/kg body weight) have potent neutralizing effect against the venom (rattle snake)[46].

**KOTHTHUMALLI (*Coriandrum sativum*)****ANTIBACTERIAL ACTIVITY**

Baratta MT et al., investigated the antibacterial potential of the leaf essential oil, petroleum ether, chloroform, ethyl acetate and methanol extracts of the leaves of *Coriandrum sativum* against human pathogenic bacteria (*Bacillus cereus*, *Enterobacter faecalis*, *Salmonella paratyphi*, *Staphylococcus aureus*, *Escherichia coli*, *Proteus vulgaris*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Serratia marcescens*) by agar well diffusion method[47].

**ANTIMICROBIAL ACTIVITY**

Silva F et al., evaluated the antimicrobial activities of essential oils against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Candida albicans* by microdilution method. The essential oils of *Coriandrum sativum* fruits obtained by hydrodistillation (HD EO) showed greater activity against *Staphylococcus aureus* and *Candida albicans* than that obtained by microwave-assisted hydrodistillation (MAHD EO). Moreover, their activities against *E. coli* and *P. aeruginosa* were the same with minimum inhibitory concentration, MIC 0.781 and 6.25 µl/ml, for HD EO and MAHD EO respectively[48].

**ANTIFUNGAL ACTIVITY**

Sourmaghi MH et al., assayed that Essential oils from commercial samples of coriander for their antibacterial and antifungal activities. Twenty-five genera of bacteria and one fungal species (*Aspergillus niger*) were used as test organisms. The essential oils showed a high degree of inhibition against all the tested microorganisms[49].

**ANXIOLYTIC ACTIVITY**

Pathan AR et al., examined that the anxiolytic effect of aqueous extract (50, 100, 200 mg/kg, ip) in male albino mice using elevated plus- maze as an animal model of anxiety. In the elevated plus-maze, aqueous extract at 200 mg/kg showed an anxiolytic effect by increasing the time spent on open arms and the percentage of open arm entries, compared to control group [50].

**ANTIDEPRESSANT EFFECT**

Sudha K et al., showed that the diethyl ether extract of seeds of *Coriandrum sativum* was more significant antidepressant effect than that of aqueous extract through interaction with adrenergic, dopamine-ergic and GABA-ergic system [51].

**SEDATIVE-HYPNOTIC ACTIVITY**

Rakhshandeh H et al., investigated the sleep-prolonging effect of *Coriandrum sativum* in mice. The hydroalcoholic extract (HAE) and its three fractions, water (WF), ethyl acetate (EAF) and N-butanol (NBF) were prepared from



**Hema et al.,**

*Coriandrum sativum* aerial parts and administrated to mice. The data indicated that *Coriandrum sativum* exerted sleep-prolonging action without major neurotoxic effect[52].

#### ANTICONVULSANT ACTIVITY

Rakhshandeh H et al., investigated the effects of hydroalcoholic extract of aerial parts of the plants (100, 500 and 1000 mg/kg) on brain tissues oxidative damages following seizures induced by pentylenetetrazole (PTZ) was investigated in rats. Pre-treatment with the 500 mg/kg of the extract caused a significant decreased in total thiol concentration in the cortical tissues ( $P < 0.010$ ). Accordingly, the hydroalcoholic extract of the aerial parts of *Coriandrum sativum* possessed significant antioxidant and anticonvulsant activities<sup>[52]</sup>.

#### NEUROPROTECTIVE ACTIVITY

Ghorbani A et al., studied the neuroprotective effect of *Coriandrum sativum* against glucose/serum deprivation (GSD)-induced cytotoxicity in vitro. The PC12 cells were cultivated for 24 h in standard media (high-glucose DMEM containing Fetal Bovine Serum) or for 6 h in GSD condition (glucose-free DMEM, without serum) in the absence or presence of various concentrations (0.1, 0.2, 0.4, 0.8 and 1.6 mg/ml) of hydroalcoholic extract (HAE), water fraction (WF), ethyl acetate fraction (EAF) or N-butanol fraction (NBF) of *Coriandrum sativum*. The study revealed that *Coriandrum sativum* bearing water-soluble compound(s) could induce neuroprotective activity, while, some constituents from this plant may serve as cytotoxic agents under stressful conditions like hypoglycemia[53].

#### ANTIPARASITIC ACTIVITY

Macedo IT et al., studied the antiparastic efficacy of *Coriandrum sativum* essential oils by two in vitro assays on *Haemonchus contortus* using egg hatch test (EHT) and larval development test (LDT). *Coriandrum sativum* essential oils exhibited a dose-dependent effect in the EHT, inhibiting 81.2% of *H. contortus* larvae hatching, at a concentration of 2.5 mg/ml. The effective concentration to inhibit 50% (EC50) of egg hatching was 0.63 mg/ml. In LDT, *Coriandrum sativum* at concentration of 10 mg/ml inhibited 97.8% of *H. contortus* larval development [54].

#### LARVICIDAL ACTIVITY

Chung IM et al., reported that the leaf oil had significant toxic effects against the larvae of *Aedes aegypti* with an LC<sub>50</sub> value of 26.93 ppm and an LC<sub>90</sub> value of 37.69 ppm, and the stem oil has toxic effects against the larvae of *A. aegypti* with an LC<sub>50</sub> value of 29.39 ppm and an LC<sub>90</sub> value of 39.95 ppm[55].

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**Table: 1. Herbal Ingredients of Pitha Sura Kudineer**

TAMIL / ENGLISH NAME[3]	BOTANICAL / FAMILY NAME[3]	PARTS USED[3]
Kaattu peipudal / Snake gourd	<i>Trichosanthes lobata</i> / Cucurbitaceae	Climber, leaf, root and seed
Lavangam / Cloves, clove tree	<i>Syzygium aromaticum</i> / Myrtaceae	Bud
Chukku / Dried ginger	<i>Zingiber officinale</i> / Zingiberaceae	Dried rhizome
Korai / Nut grass	<i>Cyperus rotundus</i> / Cyperaceae	Rhizome
Nilavembu / Green chiretta kalmegh, creat	<i>Andrographis paniculata</i> / Acanthaceae	Leaf and stem
Koththumalli / Coriander seeds	<i>Coriander sativum</i> / Apiaceae	Leaf and seed





## Free Radical Scavenging and Phytochemical Characterization in Aqueous Bark Extract of *Cinnamomum verum*

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### ABSTRACT

The purpose of this research was to establish the free radical attributes and phytoconstituents of an aqueous extract of *C.verum* barks. The bioactive components of *C.verum* were identified using GC-MS analysis. DPPH, Nitric oxide, and Superoxide scavenging experiments were performed. The phytoconstituents that were confirmed to be present in the qualitative analysis were then subjected to quantitative testing, which revealed concentrations of 210.68±0.937mg/g in phenols, 323.24±2.625mg/g, in tannins, 93.022±0.853 mg/g in carbohydrates, 187.87± 1.874mg/g in proteins and cardiac glycoside 2.22%. Cinnamaldehyde and Eugenol were found to be present in higher concentrations after being analysed by GC-MS. At a concentration of 250 µg /ml, the radical-scavenging effects of DPPH, Nitric oxide, and Superoxide were more effective than Ascorbic acid. Their IC<sub>50</sub> values were 66.083±0.531 µg/ml, 40.786±0.127µg/ml and 138.607±2.674 µg/ml, respectively. Further research is needed to isolate these bioactive compounds with the pharmacological profile, as their presence indicates that CV has substantial therapeutic prospects due to the high concentration of phytoconstituents observed. The results provide compelling evidence that CV can be used as a source of natural antioxidants to combat oxidative stress by scavenging free radicals.

**Keywords:** *Cinnamomum verum*, Free radicals, Antioxidants, Phytochemicals, Traditional Medicine.





## INTRODUCTION

Plants are rich in phytochemicals which are used to treat a diverse group of diseases. Medicinal plants constitute crucial components such as alkaloids, flavonoids, phenols, coumarins, and glycosides that are beneficial to human health. Due to the complexity of phytoconstituents, they have to be produced through identification, structure elucidation and isolation, bioactivity screening, extraction, and such processes have to be carried out. Spectral analysis by Infrared (IR), Ultraviolet (UV), and Mass spectrum (MS) have become crucial approaches for ascertaining the chemical structures of phytochemicals [1]. The natural antioxidant properties of these plants can eliminate the spontaneous generation of free radicals and reactive oxygen species, *in vivo*. When the antioxidant defense mechanism deteriorates, the ability to scavenge free radicals diminishes resulting in the accumulation of free radicals [2]. *Cinnamomum verum* (formerly *C. zeylanicum*), a member of Lauraceae is a perennial tree that originated from Sri Lanka, East and Middle Asia. Cinnamon is one of the antediluvian aromatic spices commonly used in recipes for beverages, desserts, pickles and so on [3]. Cinnamon is a multifaceted spice that has therapeutic effects on anti-inflammatory, anti-cancer, lipid-lowering, antimicrobial, nematocidal, insecticidal, and antidiabetic activities [4] and is also used in various types of dental problems [5]. Antioxidants are agents that prohibit or delay the oxidation of bioactive molecules. Biomolecules such as proteins, lipids, and nucleic acids are oxidized, culminating in the formation of reactive oxygen species (ROS). Antioxidants are essential for the human system to avoid or mitigate oxidative damage. Disproportion amongst the ROS and antioxidant compounds would trigger cellular injury, and higher antioxidant levels have also been attributed to a lower risk of cardiovascular diseases [6]. For the past two decades, there has been a surge in ascertaining the importance of medicinal plants. The abilities of natural antioxidants to suppress oxidative stress and their beneficial effects have been widely published [7,8]. Antioxidant supplementation is intended to reduce the devastating outcomes of ROS-induced oxidative injury [9]. This article focuses mainly on the characterization and validation of phytochemicals and antioxidant assays of free radical scavenging mechanistic effects present in the aqueous bark extract of *Cinnamomum verum*.

## MATERIALS AND METHODS

### Plant Collection & Authentication

The whole plant was collected and authenticated (BSI/SRC/5/23/2019/Tech/465) by the Botanical Survey of India, Southern Regional Centre, Coimbatore, India. Dried barks of *Cinnamomum verum* were pulverized and stored in an airtight container at room temperature.

### Extraction

100 g of cinnamon bark powder was infused with 100 ml of water in a ratio of 1:1 and macerated for 72 hours in an orbital shaker [10]. Solvents used for extracting chemical constituents of plants are in the ascending polarity as follows: chloroform < ethyl acetate < acetone < ethanol < 50% Ethanol < water.

### Preliminary Phytochemical Analysis-Qualitative

Preliminary qualitative phytochemical analysis was performed to assess the primary and secondary metabolites present in the aqueous extracts of *Cinnamomum verum* barks [11].

### Preliminary Phytochemical Analysis-Quantitative

Quantitative estimation of Total Carbohydrates [12], Total Proteins [13], Phenols [14], Tannins [15] and cardiac glycosides [16] was performed.

### Characterization: Gas Chromatography-Mass Spectroscopy

To characterize the bioactive constituents present in *Cinnamomum verum* bark extract, gas chromatography coupled to the mass spectroscopic method had been used and performed in Shimadzu QP 2010 interfaced with Elite-1 fused silica were set up with the acquisition parameters with the length of 30 m, the diameter of 0.25 mm, the thickness of



**Arul Mozhi Padmanabhan and Doss**

0.25  $\mu\text{m}$ , carrier gas as Helium, the flow rate of 1 ml/min, injection volume of 1  $\mu\text{l}$ , scan interval at 0.5sec, scan range from 40 to 1000 m/z, running time-chromatogram at 23.83 minutes and isothermal temperature of -50  $^{\circ}\text{C}$  for a minute, with an increase of 300  $^{\circ}\text{C}$  for 2 minutes in which mass spectra was observed at 70 eV. The relative percentage amount of the bioactive compounds present in the aqueous bark extract of CV was calculated by comparing its average peak area to the total areas produced in the chromatogram. Molecular names, structure and weights of the compounds were verified by comparing the spectrum of unknown compounds to the spectrum of known compounds in the NIST MS 2.0 structural library.

**Free Radical Scavenging activities**

The free radical scavenging abilities of DPPH [17], Nitric Oxide [18] and Superoxide Anion [19] in aqueous CV bark extracts were compared with Ascorbic acid as standard with a different concentration in the range of 40-200  $\mu\text{g}$ .

**Statistical Analysis**

By using GraphPad Prism, statistical data were expressed in mean  $\pm$  SD performed with independent triplicate values. Unpaired student's t-test (non-parametric) was performed to validate the significant difference between the standard and the sample at 95% confidence levels.

**RESULTS AND DISCUSSION****Preliminary Phytochemical Analysis-Qualitative**

The antioxidant and free radical scavenging properties of phytochemicals are immense. The harvesting of phytochemical constituents found in *Cinnamomum verum* barks is inefficient by using fewer polar solvents such as ethanol, acetone, chloroform, and ethyl acetate. Solvents with lower polarity, such as ethanol, acetone, chloroform, and ethyl acetate, demonstrate inefficiency in extracting phytochemical constituents from CV barks. The ability of phytochemical analytes is stronger to dissolve in aqueous, hydroethanolic and ethanolic extracts than in the rest as shown in Table 1. A higher degree of precipitation indicates the presence of abundant secondary metabolites in the aqueous extract.

**Quantitative analysis of Phytochemical constituents**

Phytochemicals found in medicinal plants are essential in the design of chemotherapeutic drugs [20]. The number of phytochemicals distributed in the aqueous extract was quantitatively determined. The aqueous extract of *Cinnamomum verum* barks had the highest content of phenols, tannins, and carbohydrates that were found to be  $210.68 \pm 0.937$  mg/g,  $323.24 \pm 2.625$  mg/g,  $93.022 \pm 0.853$  mg/g, respectively and the lowest proportion of proteins ( $187.87 \pm 1.874$  mg/g), according to the quantitative study of phytochemicals depicted in Figure 1. Tannins are water-soluble molecules with an astringent taste that possess anti-microbial activities. They also act as an inhibitor of lipid peroxidation through cyclooxygenase enzyme inhibition. Since phenols and tannins are copious in the aqueous extract of CV barks, they are certainly powerful at scavenging free radicals and serving as a strong metal chelator. Cardiac glycoside levels were found to be 2.22 gm% in the aqueous extract of the *C.verum* barks. Cardiac glycosides can impose significant action on the cardiac muscle in modest quantities in treating congestive heart failure by augmenting the force of heart contraction. In Cardiomyocytes, the binding of cardiac glycoside with  $\text{Na}^+\text{-K}^+$  ATPase increases in cytosolic  $\text{Na}^+$ , which triggers intracellular  $\text{Ca}^{2+}$  through  $\text{Na}^+/\text{Ca}^{2+}$ -exchanger. This generates a positive inotropic effect which increases cardiac contractility [21].

**Gas Chromatography-Mass Spectroscopy**

Results of GC-MS spectra analysis were portrayed in Figure 2 showing peaks of a series of compounds from *Cinnamomum verum* barks. Different bioactive compounds identified in the extracts of CV barks were listed in Table 2 along with the retention time and the percentage area of their respective peaks. Aqueous bark extract was comprised of cinnamaldehyde, 2-Ethylbenzotriazole and eugenol with about 70.2%, 15.47% and 3.92% respectively. Cinnamaldehyde and eugenol are indispensable in imbuing cinnamon's distinctive flavor and aroma [22] and are



**Arul Mozhi Padmanabhan and Doss**

influential natural food preservatives due to their antimicrobial properties (Kamatou, Vermaak & Viljoen, 2012). According to the previous experimental data, phenolic and flavonoid substances like eugenol [22] and cinnamaldehyde [24] possess antioxidant and free radical scavenging activities.

**Free Radical Scavenging activities**

Justifying the antioxidant capacity of bioactive components by a single method is questionable, so disparate analyses should be implemented with inflecting mechanistic principles. DPPH free radical scavenging activity is one of the rapid and convenient methods of analyzing reliable antioxidants. DPPH is a stable organic free radical that is purple. The possibility to donate hydrogen atoms provokes the transformation of the purple color to pale yellow, which represents the breakage of free radicals present in DPPH [25]. Nitric oxide plays numerous physiological roles in vascular homeostasis and antimicrobial activity. Nitric oxide is liberated from Sodium Nitroprusside and interacts - with oxygen, resulting in the formation of nitrite ions [26]. Nitric oxide radicals were quenched extremely at 76.4% in the aqueous extract of CV and quite moderately at 43.3% in Ascorbic acid. The concentration of the aqueous extract of CV bark extract raises in proportion to the relative increase in Nitric oxide scavenging activity due to reduced nitrite ion production (Figure 4a). IC<sub>50</sub> value for Nitric oxide radical scavenging activity for aqueous *Cinnamomum verum* bark extract and Ascorbic acid was observed to be 40.786 ± 0.127µg/ml and 10.51 ± 0.376µg/ml (Figure 4b). Nitric oxide scavenging activity ability was deduced by the antioxidants present in the aqueous extract of CV barks that competes with the oxygen leading to lessen nitrite ion production.

Superoxide formation may be directly involved in lipid peroxidation. Dismutation of these superoxide radicals results in hazardous hydroxyl radical formation through the Fenton reaction [27]. The involvement of these superoxide anions during aging and pathological events such as ischemic perfusion injury may pave the formation of H<sub>2</sub>O<sub>2</sub>, ·OH, Peroxynitrite or singlet Oxygen by the oxidative stress. The capacity of the aqueous bark extract of CV to trap the superoxide radicals shows a maximum of 64%. The findings suggest that the aqueous fractions of CV inhibited superoxide radicals are in a linear concentration-dependent manner as shown in Figure 4(a). IC<sub>50</sub> values of Ascorbic acid are 29.243 ± 0.841µg/ml and aqueous bark extracts of CV are 138.607 ± 2.674 µg/ml which were scavenged by 50% of the superoxide radical inhibition (Figure 4b).

**CONCLUSIONS**

Phytochemical analysis evidenced that a mixture of phytoactive components is present in the aqueous extracts of *C.verum*. Cinnamaldehyde, the major constituent of *C.verum* has been characterized by GC-MS studies. Of all the antioxidant activities, there was a strong correlation between the phenolic and free radical scavenging effects. The presence of hydroxyl functional groups in the phenolic components of *Cinnamomum verum* aqueous bark extract contributed significantly to its ability to scavenge free radicals. We can accentuate that the aqueous extracts of *Cinnamomum verum* barks act as a good source of antioxidants for combating oxidative stress. Intake of *Cinnamomum verum* barks and thereby the chief constituents such as Cinnamaldehyde and Eugenol may regulate and improve carbohydrate and lipid metabolisms, thereby aiding in the prevention of chronic diseases associated with the impaired metabolic flux and signaling mechanisms.

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## Arul Mozhi Padmanabhan and Doss

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**Arul Mozhi Padmanabhan and Doss**

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**Table 1. Qualitative analysis of phytochemicals in the *Cinnamomum verum* barks**

	Carbohydrates	Proteins	Phenols	Alkaloids	Flavonoids	Tannins	Glycosides	Saponins
Aqueous	++	++	+++	++	+++	+++	++	+
50% Ethanol	+	+	++	+	++	+	+	+
Ethanol	+	+	+	+	++	++	-	-
Acetone	+	-	++	-	+	+	-	-
Chloroform	-	-	+	-	+	+	-	-
Ethyl acetate	-	-	+	-	+	-	-	-

Results of preliminary phytochemical screening in different extracts such as water, ethanol, 50% Ethanol, Acetone, Chloroform and Ethyl acetate. +++: Highly present, ++: Moderately present, +: Trace, -: Absent

**Table 2. List of identified bioactive compounds in the bark extract of *Cinnamomum verum***

S.No	Peak Name	Retention Time (min)	Peak Area (%)
1.	Cinnamaldehyde	10.62	70.22
2.	2-Ethylbenzotriazole	12.286	15.47
3.	Eugenol	11.675	3.92
4.	dl-2-Phenyl-1,2-propanediol	10.387	2.02
5.	Methoxycinnamaldehyde	13.975	1.68
6.	Benzyl benzoate	16.775	1.63
7.	Cinnamyl acetate	12.886	1.07
8.	Diethyl Phthalate	14.642	0.92
9.	Caryophyllene	12.675	0.44
10.	$\beta$ -cis-Ocimene	7.976	0.4
11.	Benzene, 1-methoxy-4-pentyl-	12.453	0.27
12.	$\alpha$ -Ethynylbenzyl alcohol	14.941	0.26
13.	trans-2-Ethoxy-.beta.-methyl-.beta.-nitrostyrene	15.708	0.24
14.	Hydrocinnamaldehyde	8.831	0.21
15.	Hydrocinnamic acid	15.053	0.19
16.	$\alpha$ -Phellandrene	19.008	0.19
17.	2-Methylbenzofuran	13.142	0.18





**Arul Mozhi Padmanabhan and Doss**

18.	Linalool	7.698	0.16
19.	L- $\alpha$ -Terpineol	9.498	0.16
20.	Cyclohexane, dodecafluoro-	20.252	0.14
21.	$\beta$ -Gurjunene	14.875	0.13
22.	Methyl 14-methylpentadecanoate	18.286	0.08

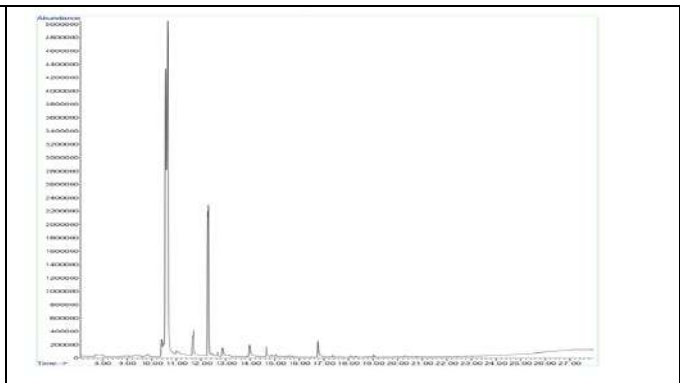
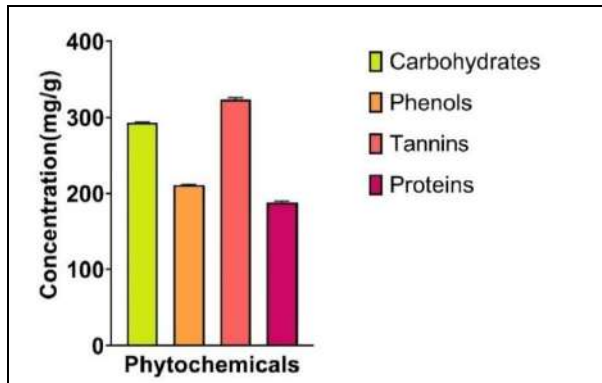


Figure 1. Quantification of phytochemicals such as carbohydrates, phenols, tannins and proteins were carried out in the aqueous extracts of CV barks

Figure 2. Typical chromatogram of GC-MS from the *Cinnamomum verum* bark extracts

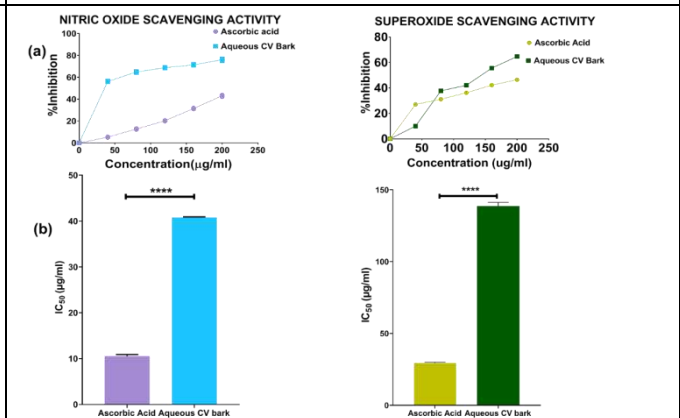
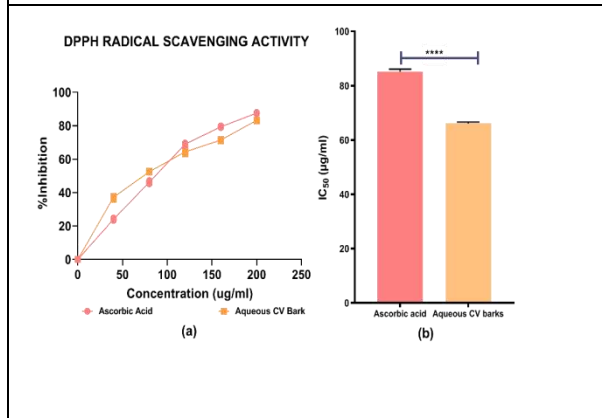


Figure 3. Effect of DPPH radical scavenging activity with (a) percentage of inhibition and (b) IC<sub>50</sub> values of Ascorbic acid and aqueous bark extract of CV. Unpaired *t*-test with the significance of \*\*\*\* indicating *p* < 0.0001.

Figure 4. Effect of free radical scavenging activities of Nitric oxide and Superoxide with (a) percentage of inhibition and (b) IC<sub>50</sub> values of Ascorbic acid and aqueous bark extract of CV. Unpaired *t*-test with the significance of \*\*\*\* indicating *p* < 0.0001.





## Analysis of Abdominal Pressure and SPO2 between Power lifters and Obese Individuals

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### ABSTRACT

Obesity has become a pressing global public health issue, contributing to a heightened risk of various comorbid conditions, including cardiovascular disease (CVD). Physical activity has been shown to mitigate the risk of hypertension, coronary heart disease (CHD), stroke, diabetes, breast/colon cancer, obesity, and depression. Power lifting, comprising the disciplines of squatting, bench pressing, and deadlifting, involves lifting substantial weights during training and competition. This study investigated SpO2 levels and abdominal pressure changes in powerlifters and obese individuals. A selection criterion includes 50 male powerlifters, individuals with a BMI exceeding 25.0, and 50 obese sedentary individuals. Once the baseline characteristics of the participants were recorded, the participants were divided into two groups. Group A, 50 individual who are doing power lifting training, and Group B, 50 individuals who are doing regular gym exercises. Participants were instructed to perform three techniques—bench press, squatting, and deadlifts—lifting weights according to their maximum capacity. Data was collected on the study's 4th week, sixth week, and eighth week. Data analysis was conducted using SPSS 24.0. The analysis, including one-way ANOVA with a p-value below 0.05, indicates significant differences. Post hoc testing revealed improvements in both exercises, with notable enhancements observed in the pre-test, immediate post-test, and one week after the intervention. As a





Rajan Balakrishnan *et al.*,

result, this study rejects the null hypothesis. This study concluded a substantial increase in abdominal pressure following exercise but no significant changes in SpO<sub>2</sub> levels following regular exercise routines. These findings shed light on the impact of power lifting techniques and obesity on physiological parameters.

**Keywords:** Power lifting techniques, Obesity, BMI, Abdominal Pressure, SpO<sub>2</sub>, Pulse oximetry,

## INTRODUCTION

Obesity is a rising global public health issue that greatly increases the chance of comorbidities, including cardiovascular disease (CVD), gastrointestinal disorders, type 2 diabetes (T2D), joint and muscle disorders, respiratory problems, and psychiatric concerns[1]. These illnesses can significantly affect patients' day-to-day lives and raise their mortality risk [2]. The risk of CVD, diabetes, obstructive sleep apnea (OSA), and hypertension, among many other obesity-related co morbidities, can be reduced in patients with modest weight loss [3]. Physical activity plays a pivotal role in mitigating the risks associated with obesity. Regular physical activity can lower the risk of hypertension, coronary vascular disease (CVD), stroke, diabetes, breast and colon cancer, and depression [4]. Surprisingly, physical inactivity is as detrimental to health as obesity and smoking, ranking the fourth-leading risk factor for global mortality, contributing to 6% of global deaths [5]. It is also the primary cause of 21-25% of breast and colon cancers, 27% of diabetes cases, and 30% of cardiovascular disease cases [6]. Despite its immense potential to improve public health, physical activity remains an underutilized resource.

Enhancing bone and functional health, improving muscular, cardiopulmonary, and respiratory fitness, lowering the incidence of falls and fractures of the hip or spine, and helping people manage their weight are all benefits of physical activity [7]. Sedentary behaviors, including sitting for longer periods by watching movies on smart phones, tablets, or television or on laptops, are increasing in our current sociocultural setting, and this tendency is predicted to continue[8]. Strength training exercises like squatting, bench pressing, and dead lifting are integral to power lifting [9]. While engaging in these activities initially elevates heart rate, the body adapts over time. It's worth noting that individuals who incorporate resistance training into their fitness routines have a 34% lower chance of developing metabolic syndrome [10]. However, there are conflicting findings regarding the impact of resistance training on metabolic syndrome components. Some studies suggest a reduction in incidence, while others find no significant effects [9,10].

Some authors argue that physiological and anatomical changes may occur as part of an adaptive process in high-performance training. The cardiovascular system can also change in response to resistance training, with the intensity of muscle contractions influencing cardiovascular responses [11]. During resistance training, concerns about an abrupt increase in blood pressure, heart rate, and cardiac output persist [12]. Therapies involving diet, physical activity, and medication may promote moderate weight or fat loss in the short term, long-term follow-up studies often yield disappointing results, as many patients tend to regain some or most of their excess weight [13]. Specific recommendations for weight-loss strategies in individuals with respiratory diseases still need to be made. The study's purpose is to assess the variations in abdominal pressure and SpO<sub>2</sub> (oxygen saturation) following resistance training, particularly in the context of power lifting. The study aims to describe physiological outcomes among groups, which is especially valuable for understanding cardiovascular and pulmonary alterations resulting from power lifting training.

## METHODOLOGY

This research project constituted a randomized controlled trial, which received ethical approval from the Institutional Ethical Committee at Garden City University in Bangalore, Karnataka. Following the approval, the





**Rajan Balakrishnan et al.,**

study recruited participants and conducted baseline assessments, including key characteristics such as age, gender, height, weight, and BMI, among other factors. The study took place at a CSJ Sports Rehab Centre, in Bangalore, where participants meeting specific criteria were enrolled. The research spanned eight weeks and targeted participants aged 25 to 45-year, male participants only, without cardiac or neurological issues, recent back or lower limb injuries, with a BMI exceeding 30 (indicative of Grade I obesity), and those with a minimum of two years of experience in power lifting exercises. Before participating, all individuals were fully informed about the research's nature, objectives, and procedures and were required to provide consent.

One hundred individuals were selected randomly from the population group of around 301, and they were all randomly selected and arranged into two equal groups. Fifty individuals were in one group, and fifty were in the second group. In Group A, 50 individuals underwent power lifting exercises; in Group B, 50 individuals underwent general exercises. Power lifters already engaged in a training regimen, including exercises like bench presses, squats, and dead lifts as a superset, while individuals dealing with obesity were provided with a eight-week training program to reduce the risk of injury. Fifty participants were randomly selected from the gym. They were all divided equally into two groups. Group A participants underwent power lifting training and group B, participants underwent general gym activities. A clear instruction was given to all the participants and written consent was obtained prior to the study.

Power lifting training regimen comprised three sessions per week, focusing on a specialized protocol involving bench presses, squats, and deadlifts as a superset. Bench press, participants were guided to exert maximum force when pushing the barbell away from their bodies while positioned on a flat exercise bench [14]. They held the barbell above their chest with palms facing away, fully extending their arms over their shoulders. Controlled breathing was emphasized, with inhalation during the lowering of the barbell toward the chest and exhalation during its ascent. Squats, recognized for their effectiveness in weight loss, involved participants performing bodyweight squats initially and gradually adding weights. They were instructed to place the barbell on their shoulders, lift it off the rack, assume a hip-distance stance, step backward, shift weight to their heels, and lower into a squat position. Throughout the squat, participants were advised to engage their core, maintain a straight back and head, and aim for a near 90-degree knee angle. To return to a standing position, they pushed through their heels, engaging their core and gluteal muscles at the peak of the squat. Dead lifting, participants held barbells upright with their feet spread wide apart, thighs slightly apart, and knees flexed at a 90-degree angle anteriorly. The same principles for squatting were applied. Before the study's commencement, abdominal pressure and SpO<sub>2</sub> levels of participants were monitored using pressure biofeedback equipment and a pulse oximeter, respectively. Data collection occurred at the study's outset and at the 4th, 6th, and 8th weeks. All collected data were subsequently analyzed using SPSS 24.0.

**Data Analysis**

The data analyses for this study utilized SPSS version 24.0 software, with a significance threshold set at a p-value below 0.05 and a 95% confidence interval for all analyses. The normality of the data was assessed using the Kolmogorov-Smirnov test. The results of this test indicated that the data for the dependent variables, namely SPO<sub>2</sub> (with a significance level of .818) and Abdominal Pressure (with a significance level of 0.321), exhibited normal distribution at p-values greater than 0.05. Given the normal distribution of the data, parametric tests were employed. Inferential statistics were employed to examine the impact of the intervention both within and between the groups. Repeated measures ANOVA were used to assess statistical differences within the groups, while one-way analysis of variance (ANOVA) was employed to identify differences between the groups. Furthermore, Post-hoc Tukey HSD multiple comparisons were conducted to determine significant differences between each group. A significance level of less than 5% (0.05) was considered statistically significant. The study's results indicate significant differences both within the exercises and between the exercises. The analysis of variance (ANOVA) conducted for the one-way ANOVA revealed a p-value lower than 0.05, implying that at least one exercise exhibited a statistically significant difference. Post hoc tests were then conducted to further examine these differences. The findings of this study demonstrate that both exercises showed improvement. Notably, significant improvements were observed during the







Rajan Balakrishnan *et al.*,

pre-test, immediately post-intervention, and one week after the intervention. Consequently, this study rejects the null hypothesis, indicating that the exercises had a positive impact on the participants.

## DISCUSSION

The primary objective of this study was to investigate the impact of power lifting techniques on abdominal pressure and SpO<sub>2</sub> response in obese individuals. The physiological consequences of intra-abdominal pressure have been a subject of considerable interest in the medical community, with prior research indicating a strong association between increased body mass index (BMI) and heightened intra-abdominal pressure [15]. Obese individuals tend to experience a 25% to 36% elevation in intra-abdominal pressure compared to their non-obese counterparts, and even morbidly obese individuals have been shown to exhibit elevated intra-abdominal pressures [16]. Furthermore, this study delved into the cardiovascular responses to exercise, revealing that resistance training, such as power lifting, can lead to significant changes [11]. Obese individuals typically have lower cardiovascular fitness levels than lean individuals, and cardiovascular responses to exercise are directly proportional to the oxygen demands of skeletal muscles for a given workload [2]. Traditional resistance exercises involve a combination of static and dynamic contractions, while power lifting techniques incorporate static contractions and heavy resistance, allowing for sufficient time to overcome the resistance load [17].

Power lifting exercises aim to enhance an individual's strength by engaging multiple muscle groups, promoting bone mineral density, stretching connective tissues, and improving muscle strength [18]. It was hypothesized that strenuous exercises could elevate intra-abdominal pressure, potentially leading to injury. The activation of the transverse abdominal muscle and body postures involving contact between the thighs and abdominal wall were found to positively correlate with intra-abdominal pressure generation. Previous research also observed increased intra-abdominal pressure during weightlifting activities [18,19]. This study also touched upon the hemodynamic changes associated with resistance exercises, including acute heart rate changes influenced by factors such as load, movement velocity, rest intervals, muscle mass involved, exercise duration, age, and training status [20]. Recent studies indicated that higher loads can lead to more significant increases in abdominal pressure and SpO<sub>2</sub> changes. The power lifting exercises utilized in this study were found to result in high values of abdominal pressure and significant SpO<sub>2</sub> changes [19].

Based on the statistical analyses and existing research, it was determined that power lifting does increase intra-abdominal pressure and affect cardiac parameters. However, these pressures tend to return to near-normal levels shortly after exercise cessation. Importantly, exercising appears to help obese individuals maintain intra-abdominal pressures within a more acceptable range. Nevertheless, this study has certain limitations. Firstly, it did not investigate the mechanisms behind changes in blood pressure and heart rate. Secondly, the choice of auscultation method for assessing blood pressure may introduce some variability. Thirdly, the study did not assess vascular resistance or sympathetic activity, and fourthly, it did not employ invasive methods for evaluation.

## CONCLUSION

In conclusion, the findings of this study offer compelling evidence of a substantial rise in abdominal pressure and noteworthy alterations in SpO<sub>2</sub> levels as a direct consequence of engaging in power lifting exercises among obese individuals. These results underscore the physiological impact of power lifting within this specific demographic and contribute valuable insights to our understanding of the effects of resistance training in individuals with obesity.





Rajan Balakrishnan et al.,

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### Conflict of Interest

The authors declare no conflicts of interest in relation to this study.

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**Rajan Balakrishnan et al.,**

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**Table 1: Comparison of SPO2 level in pretest using One ANOVA multiple comparison Post Hoc Tukey HSD Test between Group A, Group B and Group C**

MULTIPLE GROUP COMPARISON		MEAN DIFFERENCE	STANDARD ERROR	SIGNIFICANCE
GROUP A	GROUP B	-0.0145	0.0494	0.950*
	GROUP C	-0.0873	0.0492	0.686*
GROUP B	GROUP A	0.0145	0.0494	0.950*
	GROUP C	-0.0728	0.0492	0.303*
GROUP C	GROUP A	0.0873	0.0492	0.686*
	GROUP B	0.0728	0.0492	0.303*
MULTIPLE GROUP COMPARISON		MEAN DIFFERENCE	STANDARD ERROR	SIGNIFICANCE
GROUP A	GROUP B	-0.0145	0.0494	0.950*
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	GROUP C	-0.0728	0.0492	0.303*
GROUP C	GROUP A	0.0873	0.0492	0.686*
	GROUP B	0.0728	0.0492	0.303*

\*P = 0.05

The above table reveals the Mean difference, Standard Error, Multiple Group Comparison Post-Hoc Tukey test significance and p-value between (Group A) ,(Group B) & (Group C).This table 1shows that there is no significant difference in SPO2 level in Pre-Testvalues between (Group A), (Group B) & (Group C). (\*- P > 0.05)

**Table 2: Repeated Measure ANOVA was adopted to find overall changes in SPO2 level within Groups**

TEST	GROUP A		GROUP B		GROUP C	
	MEAN	S.D	MEAN	S.D	MEAN	S.D
Pre test	97.94	1.15	97.52	1.38	96.96	0.832
4 <sup>th</sup> Week	98.22	1.50	99.08	0.829	98.88	0.571
6 <sup>th</sup> Week	99.14	1.03	99.05	0.798	98.86	0.350
8 <sup>th</sup> Week	99.62	0.901	99.12	0.702	98.96	0.282
F Value	30.56		177.74		208.16	
Significance	0.000**		0.000**		0.000**	

\*P = 0.05

Repeated measures ANOVA results shows that the overall changes in the SPO2 level within the groups for all the three groups were found to have difference statistically significant at(P ≤ 0.05).

**Table 3: Comparison of Abdominal Pressure in pre-test using One ANOVA multiple comparison Post Hoc Tukey HSD Test between Group A, Group B and Group C**

Multiple Group Comparison		Mean Difference	Standard Error	Significance
GROUP A	GROUP B	1.08	1.18	0.445*
	GROUP C	2.45	1.01	0.381*





**Rajan Balakrishnan et al.,**

GROUP B	GROUP A	1.08	1.18	0.445*
	GROUP C	4.57	1.08	0.401*
GROUP C	GROUP A	2.45	1.01	0.381*
	GROUP B	4.57	1.08	0.401*

\*P = 0.05

The above table reveals the Mean difference, Standard Error, Multiple Group Comparison Post Hoc Tukey test significance and p-value between (Group A), (Group B) & (Group C). This table 3 shows that there is no significant difference in Abdominal Pressure in Pre-Test values between (Group A), (Group B) & (Group C).

**Table 4 : Repeated Measure ANOVA was adopted to find overall changes in Abdominal Pressure within Groups**

TEST	GROUP A		GROUP B		GROUP C	
	MEAN	S.D	MEAN	S.D	MEAN	S.D
Pre test	7.78	0.953	8.01	0.42	8.34	0.456
4 <sup>th</sup> Week	10.38	0.994	11.02	1.11	11.36	1.32
6 <sup>th</sup> Week	10.76	1.01	12.45	1.85	13.96	1.03
8 <sup>th</sup> Week	11.00	1.85	13.45	1.47	14.15	1.42
F Value	462.15		201.25		350.94	
Significance	0.000**		0.000**		0.000**	

\*P = 0.05

Repeated measures ANOVA results shows that the overall changes in the Abdominal Pressure within the groups for all the three groups were found to have difference statistically significant at (P ≤ 0.05).





# Area Biased Quasi Garima Distribution with Properties and its Applications among Type 2 Diabetes Patients

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## ABSTRACT

The present paper introduces Area biased Quasi Garima distribution as a new generalization of quasi Garima distribution. The different statistical properties of new distribution such as moments, order statistics, survival analysis, Bonferroni and Lorenz curves have been studied and investigated. The parameters of proposed new distribution are estimated by using the technique of maximum likelihood estimator and also its Fisher's information matrix have been discussed. Finally a new distribution has been fitted with real data sets for examining its superiority.

**Keywords:** Quasi Garima distribution, weighted distribution, Survival analysis, Order statistics, Maximum likelihood estimation.

## INTRODUCTION

The weighted distributions are applied in various research areas related to biomedicine, reliability, ecology and branching processes. In many applied sciences like medicine, engineering, behavioural science, finance, insurance and others, it is very crucial to modelling and analyzing lifetime data. For modelling this type of lifetime data, a number of continuous distributions are for modelling like weibull, lindley, exponential, lognormal and gamma. If the weight function considers the length only in units, then the weighted distribution reduces to length biased weighted distribution. Generally, the size-biased distribution is when the sampling mechanism selects the units with probability which is proportional to some measure of the unit size. The concept of weighted distribution was given





**Ramya and Subramanian**

by Fisher (1934). Later it was modified by Rao (1965) in a unified manner, where by weighted distributions many situations can be solved. Also Lappi and Bailey (1987), used size biased distributions for analysing HPS diameter increment data. Para and Jan (2018) introduced the weighted pareto type-II distribution as a new model for handling medical science data and studied its statistical properties and applications. Recently, Rather et al (2018) obtained a new size biased Ailamujia distribution with applications in engineering and medical science which shows more flexibility than classical model.

The size-biased and Area-biased distributions were discussed earlier by Fisher when sample observations have unequal probability of selection; therefore apply weights to the distribution to model bias. Area-biased distributions are an important concept in statistics. They are a type of weighted distribution that takes into account the areas associated with different observations. This approach is commonly used in various fields like ecology, epidemiology, and forestry, where the area of observation plays a crucial role in the analysis.

Quasi Garima distribution is a newly executed two parametric lifetime model proposed by Shanker et al. (2019) and the proposed quasi Garima distribution is a special case of one parameter exponential and Garima distribution. Its different mathematical and statistical properties including moments and moments based measures, hazard rate function, mean residual life function, stochastic ordering, mean deviations, Bonferroni and Lorenz curves, order statistics, Renyi entropy measure and stress strength reliability have been discussed. For estimating its parameters the two methods namely the method of moments and method of maximum likelihood estimation have been used. A goodness of fit of quasi Garima distribution have also been discussed by using a real lifetime data set from biostatistics and the fit has been found quite satisfactory over one parameter exponential, Lindley, Garima and two parameter Quasi Shanker, Gamma, Weibull and lognormal distributions. Shanker (2016) pointed out the Garima distribution with behavioral science applications, discuss its several statistical properties and estimate its parameters through method of moments and method of maximum likelihood estimation.

**Area Biased Quasi Garima Distribution**

The probability density function of Quasi Garima distribution (QGD) is given by

$$f(x; \theta, \alpha) = \frac{\theta^2}{\theta^2 + \theta + \alpha} (1 + \theta + \alpha x) e^{-\alpha x}; \quad x > 0, \theta > 0, \alpha > 0 \tag{1}$$

and the cumulative distribution function of quasi Garima distribution is given by

$$F(x; \theta, \alpha) = 1 - \left( 1 + \frac{\alpha \theta x}{\theta^2 + \theta + \alpha} \right) e^{-\alpha x}; \quad x > 0, \theta > 0, \alpha > 0 \tag{2}$$

Suppose the non-negative random variable  $X$  has probability density function  $f(x)$ . Let its non-negative weight function be  $w(x)$ , then the probability density function of weighted random variable  $X_w$  is given by

$$f_w(x) = \frac{w(x)f(x)}{E(w(x))}, \quad x > 0.$$

Where the non - negative weight function be  $w(x)$  and  $E(w(x)) = \int w(x)f(x)dx < \infty$ .

Different choices of the weight function  $w(x)$ , weighted models are of various forms particularly when  $w(x) = x^c$ , the study is called weighted distribution. In this paper, we have to study the Area biased Quasi Garima distribution, so for obtaining the area biased version of Quasi Garima distribution, we will take consequently  $w(x) = x^2$ , then the probability density function of Area Biased Distribution is given by

$$f_a(x) = \frac{x^2 f(x)}{E(x^2)} \tag{3}$$







**Ramya and Subramanian**

Where  $E(x^2) = \int_0^{\infty} x^2 f(x; \theta, \alpha) dx$

$$E(x^2) = \frac{2(\theta + \theta^2 + 3\alpha)}{\theta^2(\theta^2 + \theta + \alpha)} \tag{4}$$

Substitute equations (1) and (4) in equation (3), we will get the probability density function of Area Biased Quasi Garima distribution

$$f_a(x; \theta, \alpha) = \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} x^2 (1 + \theta + \alpha x) e^{-\theta x} \tag{5}$$

and the cumulative distribution function of Area Biased Quasi Garima distribution can be obtained as

$$F_a(x) = \int_0^x f_a(x) dx$$

$$F_a(x) = \int_0^x \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} (1 + \theta + \alpha x) x^2 e^{-\theta x} dx \tag{6}$$

Put  $\theta x = t \Rightarrow \theta dx = dt \Rightarrow dx = \frac{dt}{\theta}$ , When  $x \rightarrow x$ ,  $t \rightarrow \theta x$  and when  $x \rightarrow 0$ ,  $t \rightarrow 0$

Also  $x = \frac{t}{\theta}$

After simplification of equation (6), we will obtain the cumulative distribution function of Area biased quasi Garima distribution

$$F_a(x) = \frac{1}{2(\theta + \theta^2 + 3\alpha)} (\theta \gamma(3, \theta x) + \theta^2 \gamma(3, \theta x) + \alpha \gamma(4, \theta x)) \tag{7}$$

**Survival Analysis**

In this section, we will get the survival function, hazard rate and reverse hazard rate functions of the Area Biased Quasi Garima distribution.

**Survival function**

The survival function is defined as the probability that a system survives beyond a specified time and is also known as compliment of the cumulative distribution function. The survival function or reliability function of the Area Biased Quasi Garima distribution can be obtained as

$$S(x) = 1 - F_a(x)$$

$$S(x) = 1 - \frac{1}{2(\theta + \theta^2 + 3\alpha)} (\theta \gamma(3, \theta x) + \theta^2 \gamma(3, \theta x) + \alpha \gamma(4, \theta x))$$

**Hazard function**

The hazard function is also known as instantaneous failure rate or force of mortality and is given by





**Ramya and Subramanian**

$$h(x) = \frac{f_a(x)}{1 - F_a(x)}$$

$$h(x) = \frac{x^2 \theta^4 (1 + \theta + \alpha x) e^{-\theta x}}{2(\theta + \theta^2 + 3\alpha) - (\theta^2 \gamma(3, \theta x) + \theta \gamma(3, \theta x) + \alpha \gamma(4, \theta x))}$$

**Reverse hazard function**

The reverse hazard function of Area Biased Quasi Garima distribution is given by

$$h_r(x) = \frac{f_a(x)}{F_a(x)}$$

$$h_r(x) = \frac{x^2 \theta^4 (1 + \theta + \alpha x) e^{-\theta x}}{(\theta^2 \gamma(3, \theta x) + \theta \gamma(3, \theta x) + \alpha \gamma(4, \theta x))}$$

**Structural Measures**

In this section, various statistical properties of Area Biased Quasi Garima distribution have been investigated including its moments, harmonic mean, moment generating function and characteristic function.

**Moments**

Suppose the random variable  $X$  represents Area Biased Quasi Garima distribution with parameters  $\theta$  and  $\alpha$ , then the  $r^{th}$  order moment  $E(X^r)$  of ABQG distribution can be obtained as

$$E(X^r) = \mu_r' = \int_0^\infty x^r f_a(x) dx$$

$$E(X^r) = \mu_r' = \int_0^\infty x^r \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} x^2 (1 + \theta + \alpha x) e^{-\theta x} dx$$

$$E(X^r) = \mu_r' = \frac{\theta \Gamma(r+3) + \theta^2 \Gamma(r+3) + \alpha \Gamma(r+4)}{2\theta^r (\theta + \theta^2 + 3\alpha)} \tag{8}$$

By putting  $r = 1, 2, 3$  and  $4$  in equation (8), we will get the first four moments of length biased quasi Garima distribution.

$$E(X) = \mu_1' = \frac{3(\theta + \theta^2 + 4\alpha)}{\theta(\theta + \theta^2 + 3\alpha)}$$

$$E(X^2) = \mu_2' = \frac{12(\theta + \theta^2 + 5\alpha)}{\theta^2(\theta + \theta^2 + 3\alpha)}$$

$$E(X^3) = \mu_3' = \frac{60(\theta + \theta^2 + 6\alpha)}{\theta^3(\theta + \theta^2 + 3\alpha)}$$

$$E(X^4) = \mu_4' = \frac{360(\theta + \theta^2 + 7\alpha)}{\theta^4(\theta + \theta^2 + 3\alpha)}$$





**Ramya and Subramanian**

$$\text{Variance} = \frac{12(\theta + \theta^2 + 5\alpha)(\theta + \theta^2 + 3\alpha) - 9(\theta + \theta^2 + 4\alpha)^2}{\theta^2(\theta + \theta^2 + 3\alpha)^2}$$

$$S.D(\sigma) = \sqrt{\frac{12(\theta + \theta^2 + 5\alpha)(\theta + \theta^2 + 3\alpha) - 9(\theta + \theta^2 + 4\alpha)^2}{\theta^2(\theta + \theta^2 + 3\alpha)^2}}$$

**Harmonic mean**

The harmonic mean of proposed Area Biased Quasi Garima distribution can be obtained as

$$H.M = E\left(\frac{1}{x}\right) = \int_0^\infty \frac{1}{x} f_a(x) dx$$

$$H.M = \int_0^\infty \frac{1}{x} \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} x^2 (1 + \theta + \alpha x) e^{-\theta x} dx$$

$$H.M = \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} \left( \int_0^\infty x e^{-\theta x} dx + \theta \int_0^\infty x e^{-\theta x} dx + \alpha \int_0^\infty x e^{-\theta x} dx \right)$$

After simplification of above equation, we obtain

$$H.M = \frac{\theta}{2(\theta + \theta^2 + 3\alpha)} ((\theta + \theta^2 + 2\alpha))$$

**Moment Generating Function and Characteristic Function**

Moment generating function is another alternative specification in probability theory and statistics for finding the moments of a distribution. Let X be a random variable following Area biased Quasi Garima distribution, then the MGF of X can be obtained as

$$M_X(t) = E(e^{tx}) = \int_0^\infty e^{tx} f_a(x) dx$$

Using Taylor series, we get

$$M_X(t) = \int_0^\infty \left( 1 + tx + \frac{(tx)^2}{2!} + \dots \right) f_a(x) dx$$

$$M_X(t) = \int_0^\infty \sum_{j=0}^\infty \frac{t^j}{j!} x^j f_a(x) dx$$

$$M_X(t) = \sum_{j=0}^\infty \frac{t^j}{j!} \left( \frac{\theta \Gamma(j+3) + \theta^2 \Gamma(j+3) + \alpha \Gamma(j+4)}{2\theta^j(\theta + \theta^2 + 3\alpha)} \right)$$

$$M_X(t) = \frac{1}{2(\theta + \theta^2 + 3\alpha)} \sum_{j=0}^\infty \frac{t^j}{j! \theta^j} (\theta \Gamma(j+3) + \theta^2 \Gamma(j+3) + \alpha \Gamma(j+4))$$

Similarly, the characteristic function of ABQG distribution can be obtained as

$$\varphi_X(t) = M_X(it)$$

$$M_X(it) = \frac{1}{2(\theta + \theta^2 + 3\alpha)} \sum_{j=0}^\infty \frac{it^j}{j! \theta^j} (\theta \Gamma(j+3) + \theta^2 \Gamma(j+3) + \alpha \Gamma(j+4))$$





**Ramya and Subramanian**

**Order Statistics**

Order statistics is a useful concept in statistical sciences and have wide range of applications in modeling auctions, car races and insurance policies. Suppose  $X_{(1)}, X_{(2)}, \dots, X_{(n)}$  denote the order statistics of a random sample  $X_1, X_2, \dots, X_n$  drawn from a continuous population with probability density function  $f_X(x)$  and cumulative distribution function  $F_X(x)$ , then the probability density function of  $r^{th}$  order statistics  $X_{(r)}$  is given by

$$f_{X_{(r)}}(x) = \frac{n!}{(n-1)!(n-r)!} f_X(x) (F_X(x))^{r-1} (1-F_X(x))^{n-r} \tag{9}$$

By substituting equations (5) and (7) in equation (9), we will get the probability density function of  $r^{th}$  order statistics of Area biased Quasi Garima distribution.

$$f_{X_{(r)}}(x) = \frac{n!}{(r-1)!(n-r)!} \left( \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} x^2 (1 + \theta + \alpha x) e^{-\theta x} \right) \times \left( \frac{1}{2(\theta + \theta^2 + 3\alpha)} (\theta^2 \gamma(3, \theta x) + \theta \gamma(3, \theta x) + \alpha \gamma(4, \theta x)) \right)^{r-1} \times \left( 1 - \frac{1}{2(\theta + \theta^2 + 3\alpha)} (\theta^2 \gamma(3, \theta x) + \theta \gamma(3, \theta x) + \alpha \gamma(4, \theta x)) \right)^{n-r}$$

and the probability density function of first order statistic  $X_{(1)}$  of Area biased Quasi Garima distribution can be obtained as

$$f_{X_{(1)}}(x) = \frac{n\theta^4}{2(\theta + \theta^2 + 3\alpha)} x^2 (1 + \theta + \alpha x) e^{-\theta x} \times \left( 1 - \frac{1}{2(\theta + \theta^2 + 3\alpha)} (\theta \gamma(3, \theta x) + \theta^2 \gamma(3, \theta x) + \alpha \gamma(4, \theta x)) \right)^{n-1}$$

**Test for Area biasedness of Area Biased Quasi Garima distribution**

Suppose the random sample  $X_1, X_2, \dots, X_n$  of size  $n$  drawn from the quasi Garima distribution or area biased quasi Garima distribution. The hypothesis is to be tested.

$$H_0 : f(x) = f(x; \theta, \alpha) \quad \text{Vs} \quad H_1 : f(x) = f_a(x; \theta, \alpha)$$





**Ramya and Subramanian**

In order to investigate, whether the random sample of size  $n$  comes from the quasi Garima distribution or **Are**biased quasi Garima distribution, the test statistic is to be used.

$$\Delta = \frac{L_1}{L_o} = \prod_{i=1}^n \frac{f_a(x; \theta, \alpha)}{f(x; \theta, \alpha)}$$

$$\Delta = \frac{L_1}{L_o} = \prod_{i=1}^n \left( \frac{x_i^2 \theta^2 (\theta + \theta^2 + \alpha)}{2(\theta + \theta^2 + 3\alpha)} \right)$$

$$\Delta = \frac{L_1}{L_o} = \left( \frac{\theta^{2n} (\theta + \theta^2 + \alpha)}{2^n (\theta + \theta^2 + 3\alpha)} \right)^n \prod_{i=1}^n x_i^2$$

We should reject the null hypothesis, if

$$\Delta = \left( \frac{\theta^{2n} (\theta + \theta^2 + \alpha)}{2^n (\theta + \theta^2 + 3\alpha)} \right)^n \prod_{i=1}^n x_i > k$$

Equivalently, we reject the null hypothesis

$$\Delta^* = \prod_{i=1}^n x_i^2 > k \left( \frac{\theta^2 (\theta + \theta^2 + \alpha)}{2(\theta + \theta^2 + 3\alpha)} \right)^n$$

$$\Delta^* = \prod_{i=1}^n x_i^2 > k^*, \text{ Where } k^* = k \left( \frac{\theta^2 (\theta + \theta^2 + \alpha)}{2(\theta + \theta^2 + 3\alpha)} \right)^n$$

Thus for a large sample of size  $n$ ,  $2 \log \Delta$  is distributed as chi-square distribution with one degree of freedom and also  $p$  value is getting from the chi-square distribution. Also, we refuse to accept the null hypothesis, when the probability value is given by

$p(\Delta^* > \lambda^*)$ , Where  $\lambda^* = \prod_{i=1}^n x_i^2$  is less than a specified level of significance. Where  $\prod_{i=1}^n x_i^2$  is the observed value of the statistic  $\Delta^*$ .

**Bonferroni and Lorenz Curves**

The bonferroni and lorenz curves are also known as income distribution curves and are used in economics to study the distribution of inequality in income or poverty. Now a days it is also being used in various other fields like reliability, medicine, insurance and demography. The bonferroni and lorenz curves are defined as

$$B(p) = \frac{1}{p\mu_1'} \int_0^q xf(x)dx$$

$$L(p) = pB(p) = \frac{1}{\mu_1'} \int_0^q xf(x)dx$$

Where  $\mu_1' = \frac{3(\theta + 2\theta^2 + 4\alpha)}{\theta(\theta + \theta^2 + 3\alpha)}$  and  $q = F^{-1}(p)$





**Ramya and Subramanian**

$$B(p) = \frac{\theta(\theta + \theta^2 + 3\alpha)}{p3(\theta + \theta^2 + 4\alpha)} \int_0^q \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} x^3 (1 + \theta + \alpha x) e^{-\theta x} dx$$

$$B(p) = \frac{\theta^5}{6p(\theta + \theta^2 + 4\alpha)} \int_0^q x^3 (1 + \theta + \alpha x) e^{-\theta x} dx$$

$$B(p) = \frac{\theta^5}{6p(\theta + \theta^2 + 4\alpha)} \left( \int_0^q x^{4-1} e^{-\theta x} dx + \theta \int_0^q x^{4-1} e^{-\theta x} dx + \alpha \int_0^q x^{5-1} e^{-\theta x} dx \right)$$

After simplification of above equation, we get

$$B(p) = \frac{\theta^5}{6p(\theta + \theta^2 + 4\alpha)} (\gamma(4, \theta q) + \theta \gamma(4, \theta q) + \alpha \gamma(5, \theta q))$$

$$L(p) = \frac{\theta^5}{6(\theta + \theta^2 + 4\alpha)} (\gamma(4, \theta q) + \theta \gamma(4, \theta q) + \alpha \gamma(5, \theta q))$$

**Maximum Likelihood Estimation and Fisher’s Information Matrix**

In this section, we will discuss the parameter estimation of Area Biased Quasi Garima distribution by using the technique of maximum likelihood estimator and also derive its Fisher’s information matrix. Suppose the random sample  $X_1, X_2, \dots, X_n$  of size  $n$  drawn from the Area Biased Quasi Garima, then the likelihood function can be written as

$$L(x) = \prod_{i=1}^n f_a(x)$$

$$L(x) = \prod_{i=1}^n \left( \frac{\theta^4}{2(\theta + \theta^2 + 3\alpha)} x_i (1 + \theta + \alpha x_i) e^{-\theta x_i} \right)$$

$$L(x) = \frac{\theta^{4n}}{2^n (\theta + \theta^2 + 3\alpha)^n} \prod_{i=1}^n \left( x_i^2 (1 + \theta + \alpha x_i) e^{-\theta x_i} \right)$$

The log likelihood function is given by

$$\log L = 4n \log \theta - n \log 2 - n \log(\theta + \theta^2 + 3\alpha) + \sum_{i=1}^n \log x_i + \sum_{i=1}^n \log(1 + \theta + \alpha x_i) - \theta \sum_{i=1}^n x_i \tag{10}$$

Now differentiating the above equation (10) with respect to parameters  $\theta$  and  $\alpha$ . We obtain the normal equations as

$$\frac{\partial \log L}{\partial \theta} = \frac{4n}{\theta} - n \left( \frac{2n\theta}{(\theta + \theta^2 + 3\alpha)} \right) + \sum_{i=1}^n \left( \frac{1}{(1 + \theta + \alpha x_i)} \right) - \sum_{i=1}^n x_i = 0$$

$$\frac{\partial \log L}{\partial \alpha} = -n \left( \frac{3}{(\theta + \theta^2 + 3\alpha)} \right) + \sum_{i=1}^n \left( \frac{x_i}{(1 + \theta + \alpha x_i)} \right) = 0$$

The above system of nonlinear equations are too complicated to solve it algebraically, therefore we use numerical technique like Newton-Raphson method for estimating the required parameters of the proposed distribution.

We use the asymptotic normality results to obtain confidence interval, we have that if  $\hat{\lambda} = (\hat{\theta}, \hat{\alpha})$  denotes the MLE of  $\lambda = (\theta, \alpha)$ . We can state the results as follows.

$$\sqrt{n}(\hat{\lambda} - \lambda) \rightarrow N_2(0, I^{-1}(\lambda))$$

Where  $I^{-1}(\lambda)$  is Fisher's information matrix. i.e.,







**Ramya and Subramanian**

$$I(\lambda) = -\frac{1}{n} \begin{pmatrix} E\left(\frac{\partial^2 \log L}{\partial \theta^2}\right) & E\left(\frac{\partial^2 \log L}{\partial \theta \partial \alpha}\right) \\ E\left(\frac{\partial^2 \log L}{\partial \alpha \partial \theta}\right) & E\left(\frac{\partial^2 \log L}{\partial \alpha^2}\right) \end{pmatrix}$$

Where

$$E\left(\frac{\partial^2 \log L}{\partial \theta^2}\right) = -\frac{4n}{\theta^2} - n \left( \frac{2(\theta + \theta^2 + 3\alpha) - 2\theta(2\theta + 1)}{(\theta + \theta^2 + 3\alpha)^2} \right) - \sum_{i=1}^n \left( \frac{1}{(1 + \theta + \alpha x_i)^2} \right)$$

$$E\left(\frac{\partial^2 \log L}{\partial \alpha^2}\right) = \left( \frac{n}{(\theta + \theta^2 + 3\alpha)^2} \right) - \sum_{i=1}^n \left( \frac{x_i^2}{(1 + \theta + \alpha x_i)^2} \right)$$

$$E\left(\frac{\partial^2 \log L}{\partial \theta \partial \alpha}\right) = \left( \frac{6n\theta}{(\theta + \theta^2 + 3\alpha)^2} \right) - \sum_{i=1}^n \left( \frac{x_i}{(1 + \theta + \alpha x_i)^2} \right)$$

Since  $\lambda$  being unknown, we estimate  $I^{-1}(\lambda)$  by  $I^{-1}(\hat{\lambda})$  and this can be used to obtain asymptotic confidence intervals for  $\theta$  and  $\alpha$ .

**Data Analysis**

In this section, we have discussed the goodness of fit by analysing real data set in Area biased Quasi Garima distribution to show that Area biased quasi Garima distribution fits better as compared to quasi Garima, Garima, exponential and Lindley distributions. 550 subjects were randomly selected from various hospitals in the two districts, Palakkad and Malappuram - at Kerala to make real data analysis. R software is employed to estimate the unknown parameters along with the model comparison criterion values. In order to compare the ABQG distribution with quasi Garima, Garima, exponential and Lindley distributions, we apply the *AIC* (Akaike Information Criterion), *AICC* (Akaike Information Criterion Corrected), *BIC* (Bayesian Information Criterion) and  $-2\log L$ . The better distribution is which corresponds to lower values of *AIC*, *BIC*, *AICC* and  $-2\log L$ . For calculating *AIC*, *BIC*, *AICC* and  $-2\log L$  can be evaluated by using the formulas as follows:

$$AIC = 2k - 2\log L, \quad BIC = k \log n - 2\log L \quad \text{and} \quad AICC = AIC + \frac{2k(k+1)}{n-k-1}$$

Where  $k$  is the number of parameters in the statistical model,  $n$  is the sample size and  $-2\log L$  is the maximized value of log-likelihood function under the considered model.

From results given above table it has been clearly observed that the area biased quasi Garima distribution have the lesser *AIC*, *BIC*, *AICC* and  $-2\log L$  values as compared to quasi Garima, Garima, exponential and Lindley distributions. Hence it can be concluded that the Area biased quasi Garima distribution leads to a better fit as compared over quasi Garima, Garima, exponential and Lindley distributions.

**CONCLUSION**

The present article describes a new model of two parameter quasi Garima distribution named as Area Biased Quasi Garima distribution. The subject distribution is generated by using the Area biased technique. Its various statistical properties including its moments, harmonic mean, moment generating function, characteristic function, order statistics, Bonferroni and Lorenz curves have been investigated. Its parameters have also been estimated by using the method of maximum likelihood estimation. Lastly, a real data set have been applied in Area biased quasi Garima



**Ramya and Subramanian**

distribution to discuss its goodness of fit and the fit of Area biased quasi Garima distribution has been found good in comparison over quasi Garima, Garima, exponential and Lindley distributions.

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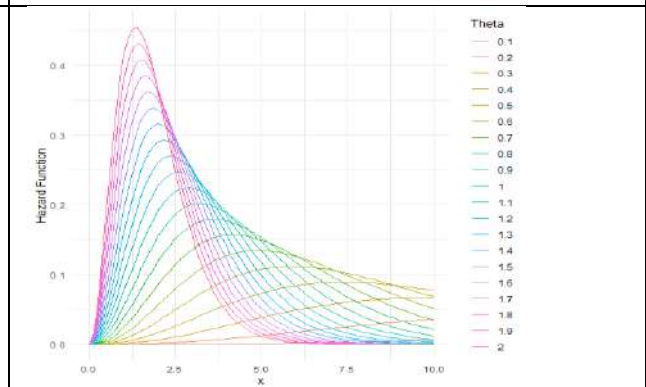
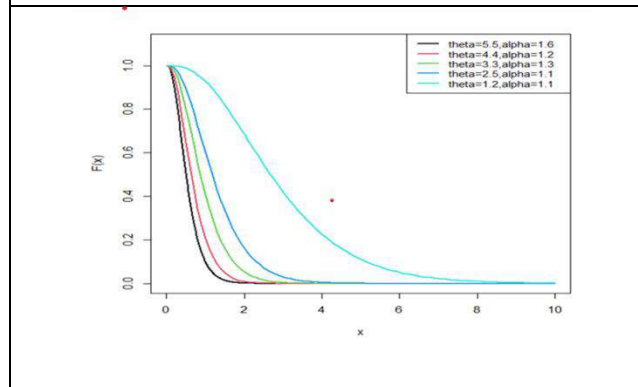
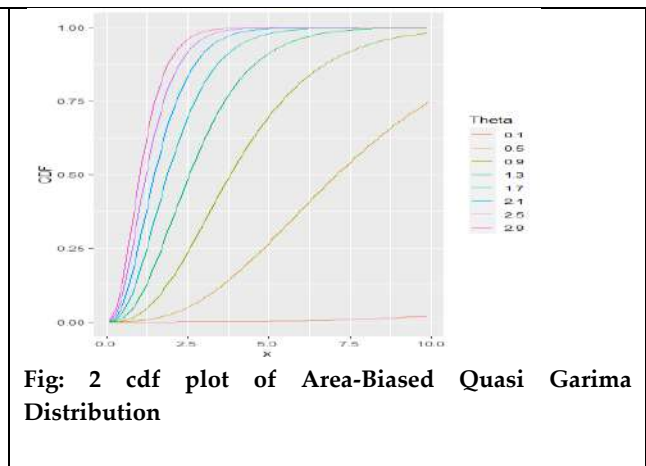
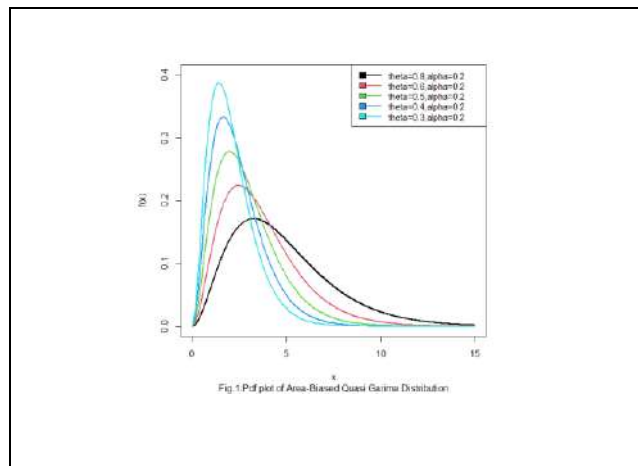




**Ramya and Subramanian**

**Table 1: Comparison of fitted distributions**

Distribution	MLE	S.E	-2logL	AIC	BIC	AICC
Area Biased Quasi Garima	$\hat{\alpha} = 3.035280$ $\hat{\theta} = 9.736420$	$\hat{\alpha} = 5.058758$ $\hat{\theta} = 1.009555$	240.4692	244.4692	247.3371	244.8977
Quasi Garima	$\hat{\alpha} = 3.548881$ $\hat{\theta} = 6.490944$	$\hat{\alpha} = 4.653411$ $\hat{\theta} = 8.241942$	252.2362	256.2362	259.1042	256.6647
Garima	$\hat{\theta} = 0.051574443$	$\hat{\theta} = 0.007885039$	267.278	269.278	270.712	269.4159
Exponential	$\hat{\theta} = 0.032460724$	$\hat{\theta} = 0.00582457$	274.5289	276.5289	277.9629	276.6668
Lindley	$\hat{\theta} = 0.062990212$	$\hat{\theta} = 0.008004775$	253.9884	255.9884	257.4224	256.1263





## *In-Vitro* Carminative Activity of A Polyherbal Siddha Formulation– *Panchadeepakini Legium*

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### ABSTRACT

Siddha system of medicine is a holistic approach to treating vast diseases and also paves the way for healthy living. Nowadays people living with hectic lifestyles are overblown with digestive problems like hyperacidity, burning or dull pain in the stomach, and belching. Anti- ulcer, carminative drugs are used for relieving digestive problems. Many herbal drugs are found to have carminative properties. This study deals with the polyherbal formulation *Panchadeepakini legium* (PDL) documented in classic Siddha literature *Siddha vaithiyathirattu* which is indicated for *pithavayou*, *erichal*, *porumal*. The five spices of PDL are “driedginger (*Zingiber officinale*), black pepper (*Piper nigrum*), long pepper (*Piper longum*), cardamom (*Elettaria cardamomum*), cumin (*Cuminum cyminum*)”. The intention of the research is to appraise the invitro carminative activity of PDL by the Acid-base titration method. The results of this study revealed the carminative activity of *Panchadeepakini legium* at different doses.

**Keywords:** Siddha medicine, antiulcer, carminative, *panchadeepakini legium*





Swathi et al.,

## INTRODUCTION

Siddha is a unique antiquity system of medicine practiced mostly in southern India. It is based on the literature written by the great saint Siddhars. According to Siddha, there are 4448 diseases [1]. In this modern era, the digestive problem is one of the common illnesses affecting 20% of the population. Only 10% of those affected will seek medical treatment [2]. There is a wide range of medicines available to treat digestive disorders. Most of the polyherbal Siddha formulation has the carminative property that prevents gas formation in the gastrointestinal tract and eases the voiding of gas and it also cures other digestive illnesses. Carminatives are oftentimes combinations of herbal spices and essential oils [3]. Spices are well recognized as antacid and carminative. In *Siddha vaithiya thirattu*, the polyherbal medicine *Panchadeepakini legium* is indicated for indigestion, ulcer, flatulence, and gastric irritation [4]. The medicine is composed of dried ginger (*Zingiber officinale*), black pepper (*Piper nigrum*), long pepper (*Piper longum*), cardamom (*Elettaria cardamomum*), cumin (*Cuminum cyminum*), honey, ghee, milk, and palm jaggery. The objective of the current work is to assess *Panchadeepakini legium* scientifically for its carminative property by using the modified method of Swapnil Sharma et al. acid-base titration method.

## MATERIALS AND METHODS

### Collection of raw drugs

The raw drugs were procured from Guruji raw drug store, Tambaram, Chennai, Tamil Nadu, India.

### Authentication

Raw drugs were verified by the Medicinal Botanist of the National Institute of Siddha, Chennai. The sample drug *Panchadeepakini legium* was prepared at Gunapadam lab, National Institute of Siddha, Chennai-47.

### Ingredients of the test drug [4],[5]

1. Elam (*Elettaria cardamomum*)
2. Seeragam (*Cuminum cyminum*)
3. Sukku (*Zingiber officinale*)
4. Milagu (*Piper nigrum*)
5. Thippili (*Piper longum*)
6. Cow's milk
7. Pannaivaellam (Palm jaggery)
8. Nei (Ghee)
9. Thaen (Honey)

### Preparation of Panchadeepakini legium

The above-mentioned five spices are roasted and made as a fine powder. Dissolve palm jaggery in cow's milk and filtered it to remove any impurities and then boiled it until paagu patham. In this stage gradually added the fine powder, and ghee and mixed them together. After the mixture cools down, mixed it with honey and made it to mezhugu patham. Then stored in an air-tight container.

### Dosage

6 grams twice a day, 48 days

### Indication

Vatham, pithavayvu, indigestion, flatulence, diarrhea, vomit





Swathi et al.,

**Reference**

Siddha vaithiya thirattu, Pg no: 237- 238

**In-vitro Carminative Activity**

Project ID : NRS/AS/1048/02/2023 Institute : National Institute of Siddha Sample name : *Panchadeepakini legium* (PDL) Sample ID : PDL

**In-vitro Carminative Activity by acid-base titration Method**

In-vitro carminative activity of the Siddha formulation was evaluated by the modified method of *Swapnil Sharma et al* [13]. About 0.5, 1 and 2 gm of the PDL in water were placed in a conical flask fitted with an air-tight nozzle, to this quantity sufficient distilled water was added. About 100 ml of NaOH [1M, previously standardized to oxalic acid] was poured into a plastic container fitted with an aeration tubing system that was connected directly to the reaction vessel containing varying volumes of the test sample. The flask was agitated manually for the next 45 mins and vigorously for another 30 mins and was allowed to stand for overnight. The carbon dioxide gas evolved from the reaction vessel and was allowed to pass into a plastic container containing excess sodium hydroxide where it was absorbed and converted into an equivalent amount of sodium carbonate. The resulting mixture consisting of excess sodium hydroxide and sodium carbonate was titrated with standard HCl using phenolphthalein as an indicator to get the first endpoint and in continuation, to this, the second endpoint was enumerated using methyl orange as an indicator. The difference in milliliter between the first & second endpoints was used to calculate the carbon dioxide content per gram of sample [14]. Vol. of titrant x molarity of std. acid x mol. Wt. of CO<sub>2</sub> = mass of CO<sub>2</sub> in gm  
The molarity of the Acid is 0.09184 M  
Mol. Wt. of CO<sub>2</sub> is 44.01 g/mol

**RESULT AND DISCUSSION**

It is encouraged that herbal medicine for digestive illnesses can be used as the treatment of choice because they cure the symptoms by nourishing the digestive system and also they result in little or no harmful effects. The carminative profiling of the test sample was evaluated on the basis of the amount of Carbon dioxide evolved from the reaction mixture with the varying volume of the test sample. The amount of carbon dioxide {g} produced by the 0.5 gm of the PDL sample was found to be (9.7 ± 2.02), for 1 gm of sample it was (11.72 ± 1.62) and for 2 gm of the sample, it was (16.57 ± 1.21).

**CONCLUSION**

In the present study, we have evaluated the carminative activity of Siddha polyherbal medicine *Panchadeepakini legium* using the acid-base titration method. The result of the present investigation shows that the Siddha formulation PDL possesses promising carminative activity in the tested medium which was measured as an index of the mass of CO<sub>2</sub> released from the medium. Further studies of PDL in In-vivo screening will be more helpful for the drug for clinical application. Thus, it is concluded that *Panchadeepakini legium* has potent carminative activity.

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Table 1: Particulars of the ingredients of Panchadeepakini legium

S.No	Common name (English/Tamil)	Botanical Name and Family	Phytochemicals	Actions
1.	Sukku (Dry ginger)	<i>Zingiber officinale</i> / <i>Zingiberaceae</i>	Omega glycerol, gingerol, zingerone, cosanic acid, $\beta$ -sitosterol [6], [7]	Carminative Stomachic Digestive [12]
2.	Milagu (Pepper)	<i>Piper nigrum</i> / <i>Piperaceae</i>	Carotinoides, thyone, pinene, caryophyllene, linalool [6], [8]	Antivata Carminative Antiperiodic Antidote [12]
3.	Thippili (Long pepper)	<i>Piper longum</i> / <i>Piperaceae</i>	Prolidine, $\beta$ -caryophyllene piperolactum, coumaperine [6], [9]	Carminative Stimulant [12]
4.	Elam (Cardamomum)	<i>Elettaria cardamomum</i> / <i>Zingiberaceae</i>	Flavonoids, terpenoids, carotenoids [6], [10]	Stimulant Carminative Stomachic [12]
5.	Seeragam (Cuminum)	<i>Cuminum cyminum</i>	Alkaloids, terpenoids, Flavonoids [11]	Carminative Stimulant Astringent [12]





Swathi et al.,

**Table 2: Triplicate 1**

Test Sample Grams	The difference in Titration value (ml)	Mass of CO <sub>2</sub> in gm
0.5	1.6	7.68
1	2.2	10.10
2	2.9	15.36

**Table 3: Triplicate 2**

Test Sample Grams	The difference in Titration value (ml)	Mass of CO <sub>2</sub> in gm
0.5	1.5	9.70
1	2.1	11.72
2	3.2	16.57

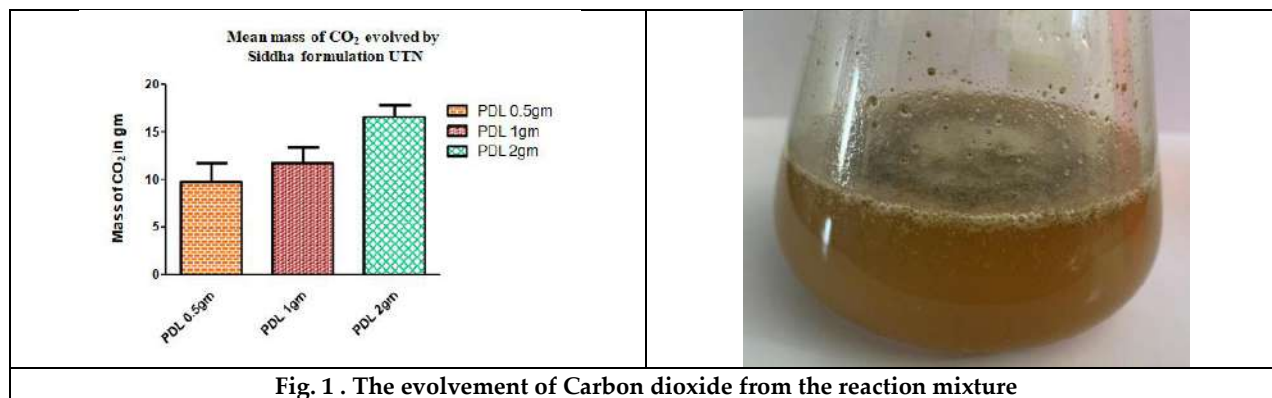
**Table 4: Triplicate 3**

Test Sample Grams	The difference in Titration value (ml)	Mass of CO <sub>2</sub> in gm
0.5	1.6	11.72
1	2	13.34
2	3.6	17.78

**Table 5: Statistical Representation**

Test Sample Grams	Mass of CO <sub>2</sub> in gm
0.5	9.7 ± 2.02
1	11.72 ± 1.62
2	16.57 ± 1.21

Each value represents the mean ± SD. N=3



**Fig. 1 . The evolvement of Carbon dioxide from the reaction mixture**





## Bioconversion of Chicken Feather Waste in to Biofortified Compost using Keratinolytic Fungi

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### ABSTRACT

Poultry industry is amongst the most advanced agribusiness production chains in the world. In India, more than 70% poultry sector comes under organized market. There is an increasing demand for poultry meat and egg mainly due to its acceptance by most societies and its relatively low cholesterol content. In spite of economical and successful, the poultry industry is currently facing a major problem facing *i.e.* accumulation of wastes including feather and litter which may pose disposal and pollution problems. The study was undertaken for the conversion of chicken feather waste into biofortified compost using keratinolytic fungi *Aspergillus* sp, *Trichoderma* sp and *Fusarium* sp were isolated from chicken feather dumped soil sample using potato dextrose agar and sabouraud dextrose agar media. Isolates were inoculated into the processed chicken feather and sterile soil separately. The isolates showed different ranges in degradation of chicken feather waste. This study showed the degradation capacity of *Aspergillus* sp, *Trichoderma* sp and *Fusarium* sp on chicken feather waste and also showed the effect of biofortified compost on tomato. Results of this study provide much less hazardous, cheap and eco friendly for the conversion of chicken feather waste into biofortified compost.

**Keywords:** Chicken feather waste, Biofortified compost, Keratinolytic fungi, Less hazardous.



**Kannahi and Lakshmi Priya****INTRODUCTION**

Keratinous wastes constitute a trouble, some environmental contaminant that is produced in large quantities in commercial poultry processing plants and their utilization is of economic value as well as ecological significance. Feather waste make a serious problem as environmental pollutant and recently in outbreaks of H1NI virus. Soil that is rich in keratinous materials is conducive to the growth of keratinophilic microorganisms such as fungi. Keratin is the most abundant and highly stable animal protein on earth (Mercantini, 1980) therefore keratinophilic species are ecologically important microorganisms. Biodegradation by microorganisms possessing keratinolytic activity represents an alternative attractive method for improving the nutritional value of keratin wastes, as it offers cheap and mild reaction conditions for the production of valuable products (Kim *et al.*, 2001). Keratinophilic fungi are ecologically an important group of fungi which could be found in soil. Some groups of these fungi are causative agents of cutaneous fungal infections named dermatophytosis, and the other saprophyte fungi mainly represent hyphomycosis (Palsson, 1968).

Keratin is a fibrous and insoluble structural protein extensively cross-linked with disulphide, hydrogen and hydrophobic bonds, resulting in mechanical stability and resistance to common proteolytic enzyme such as pepsin, trypsin and papain. These feathers constitute a sizable waste disposal problem. Several different approaches have been used for disposing of feather waste, including land filling, burning, natural gas production and treatment for animal feed. Most feather waste is land filled or burnt which involves expense and can cause contamination of air, soil and water (Joshi *et al.*, 2007). Composting is the natural process of recycling organic matter, such as leaves and food scraps, into a valuable fertilizer that can enrich soil and plants. Anything that grows decomposes eventually; composting simply speeds up the process by providing an ideal environment for bacteria, fungi, and other decomposing organisms (such as worms, sowbugs, and nematodes).

**MATERIAL AND METHODS****Collection of Chicken Feather Waste and Soil Sample (Mini *et al.*, 2015)**

The chicken feather waste and soil sample was collected from the dumping site of chicken feather waste nearby, Vaduvur, Thiruvarur District, Tamil Nadu, India in a sterile polythene bag and brought to the laboratory for further evaluation.

**Analysis of Physicochemical Parameters Soil (Sullivan And Millar, 2000)**

The physicochemical parameters such as pH, temperature, moisture content, electrical conductivity, etc of soil was analyzed before treatment using standard protocols.

**Isolation of Fungi (Aneja, 2006)**

Serial dilution was performed by using the collected soil sample to isolate the fungal population. The soil sample was diluted in conical flask containing 90 ml of sterile distilled water and mixed thoroughly to make 1: 10 dilution ( $10^{-1}$ ). Then 10ml of diluted sample was transferred to the next flask and serially diluted into the series of conical flasks having 90ml of sterile distilled water with sterile pipettes, up to  $10^{-6}$ . Hence, the  $10^{-4}$  to  $10^{-6}$  dilutions were taken for the fungal isolation. Soil sample was taken from the container and subjected to serial dilution followed by pour plate method. Then these soil suspended dilutions were spread over potato dextrose agar (PDA) medium on isolate keratinolytic fungal strains and incubated for 5 days in incubator at 28°C. Every dilution was processed in triplicates. After 5 days of incubation the isolated fungal strains were pure cultured on sabouraud dextrose agar (SDA) medium (Warcup, 1950).

**Identification of Keratinolytic Fungi**

Pure cultures of fungal strains were identified on the basis of macroscopic and microscopic analysis of fungal colonies. Isolated fungal strains were identified on the basis of morphology up to genus and species level.





### Kannahi and Lakshmipriya

Macroscopic features like color, shape, texture and size of colony were observed. Microscopic features like vesicle, septation of hyphae, conidiophore, metulae and phialides, were examined. This examination was carried out through the staining of fungus with lacto-phenol cotton blue.

#### Processing of Chicken Feather

The chicken feathers were washed thoroughly with tap water and were air dried. The dried feathers were purified by soaking in sodium lauryl sulfate for 2 hrs and were washed again thoroughly with distilled water, air dried and autoclaved at 121°C for 15 mins.

#### Degradation of Chicken Feather Waste into Biofortified Compost (Sankar and Chourasia, 2017)

Three sets containing 30g of processed chicken feather organic waste was prepared. These three sets were inoculated individually by three different fungi with 5% inoculums to estimate the capability of these fungi for the degradation of waste material. One set were inoculated with *Aspergillus* sp, second set was inoculated with *Trichoderma* sp and the third set were inoculated with *Fusarium* sp. One set was maintain as control group under same experimental conditions. Periodically, the samples were taken for the estimation of waste degradation at the regular intervals of ten days up to thirty days and the waste material degradation was estimated.

#### Analysis of Physicochemical Parameters Biofortified Compost (Sullivan and Millar, 2000)

The physicochemical parameters such as pH, temperature, moisture content, electrical conductivity, mass reduction, etc of biofortified compost was analyzed separately using standard protocols.

## RESULT

#### Analysis of Physico – Chemical Parameters of Dumped Soil Sample

The physicochemical parameters such as pH, Temperature, Moisture, Electrical conductivity, Nitrogen, Phosphorus, Potassium and Carbon were tested before and after inoculation and the above said parameters were increased after compost inoculation treatments.

#### Identification of Keratinolytic Fungi

Six different species of fungi were observed from chicken feather dumped soil sample. The colonies showed a characteristic colour of green, yellow and black. They were confirmed by identifying their morphological characters. Isolate 1 showed slightly blackish colored colony with large sized biserial phialides and 26 °C was the optimum temperature for its growth. Conidial shape was globose with very rough irregular surface. This strain was identified as *Aspergillus* sp. Isolate 2 showed dark green to dark bluish green sporulation, colony reverse was amber or uncoloured. conidiophore usually long, infrequently branched, verticillate conidiophores. Phialides frequently paired, lageniform convergent. Conidial shape was globose to ellipsoidal. Formation of chlamydospore infrequent or frequent producing terminally and intercalary. Based on these features these isolates were identified as *Trichoderma* sp.

Isolate 3 showed hyphae are joined by clamp connection, haploid basidiospore, conidia globose, white or more pale often lilac – gray colonies was identified as *Pleurotus* sp. Isolate 4 showed aseptate conidiospore, conidio globose and white and fluffy in appearance. Sporangia blackish, brown was identified as *Rhizopus* sp. Isolate 5 showed different colony colors: dull pink, pink, creamy white and white. The isolates imparted dull white, orange, light reddish purple, intense reddish purple and dark reddish purple pigmentation. Macroconidia were formed on mycelial conidiophores and were straight with 1-5 septated and of medium length. Microconidia were small to large and mostly non septated. Chlamydospores are single, pairs and occasionally in clumps at intercalary and terminal positions and phialides were short. Based on the features these isolates were identified as *Fusarium* sp.



**Kannahi and LakshmiPriya**

Isolate 6 showed vegetative hyphae, conidiospore, club shaped smooth spores and white colour dical to ellipsoidal shape was identified as *P. chrysosporium*. In this soil sample, nearly 6 fungal species were isolated and identified namely *Aspergillus* sp, *Trichoderma* sp, *Rhizopus* sp, *Pleurotus* sp, *Trichoderma* sp, *Fusarium* sp and *P.chrysosporium*. Six different fungi were identified from the chicken feather dumped soil sample. Among this fungi, three different keratinolytic fungi was predominantly found on the chicken feather dumped soil sample. Among these fungi, three keratinolytic fungi were selected for further study.

**Degradation of Chicken Feather Waste into Biofortified Compost (Masooda et al., 2023)**

Different parameters of the compost were calculated as follow,

**Estimation of pH**

The measurement of hydrogen ion activity is pH and it depends on hydrogen and metallic ion absorbent. Initially the pH was same i.e. 7.1. With the passage of time, slight increase in pH was observed (Table-3). At the termination of experiment the calculated pH of *Aspergillus* sp degraded biofortified compost was 8.02. However, 8.1 and 8.08 pH was recorded by *Trichoderma* sp degraded biofortified compost and *Fusarium* sp degraded biofortified compost experimental groups respectively. While, there was no significant difference in control group.

**Change in Temperature**

Change in temperature was estimated after 10 days interval. A rapid increase in temperature was observed in *Aspergillus* sp degraded biofortified compost after twenty days. At the termination of experiment 49 °C was recorded by *Trichoderma* sp. While 43°C and 36°C temperature was recorded by *Trichoderma* sp degraded biofortified compost and *Fusarium* sp degraded biofortified compost, respectively at the termination of experiment.

**Estimation of Electrical Conductivity**

The ability to transfer the charge is electrical conductivity. The value of electric conductivity was high at the beginning of the experiment. But at the termination of experiment the value of electric conductivity of *Aspergillus* sp degraded biofortified compost was 0.19 (ms/cm). While *Trichoderma* sp degraded biofortified compost and *Fusarium* sp degraded biofortified compost showed 0.32 and 0.35 (ms/cm) electric conductivity, respectively.

**Estimation of Moisture Content in Compost**

In composting process, water is a very critical factor. Initially, the moisture content was uniform in all the groups which indicated that the reduction of moisture was due to evaporation or drying. 50% of moisture reduction was calculated by *Aspergillus* sp degraded biofortified compost. 51% and 58% decrease in moisture content was recorded by *Trichoderma* sp degraded biofortified compost and *Fusarium* sp degraded biofortified compost, respectively.

**Estimation of organic matter**

Organic matter is important for maintaining the water holding capacity, availability of nutrients and structure of soil. The absolute amount of organic matter is not fixed. It may range from 30-70%. But organic matter in compost must be above 30% (US Composting Council, 2003). Initially, the value of organic matter was low. But with the passage of time it started increasing. At the determination of experiment the value of organic matter by *Aspergillus* sp degraded biofortified compost was 50%. While, *Trichoderma* sp degraded biofortified compost and *Fusarium* sp degraded biofortified compost contained 43% and 36% of organic matter, respectively.

**Estimation of mass degradation and physical changes in compost**

A rapid decrease was observed in all three experimental groups as well as in control groups in initial two weeks. However, the *Aspergillus* sp degraded biofortified compost experimental group showed maximum decrease in waste mass as compared to *Trichoderma* sp degraded biofortified compost and *Fusarium* sp degraded biofortified compost experimental groups. After the trial of thirty days, 73% reduction of waste mass by





**Kannahi and Lakshmipriya**

*Aspergillus* sp degraded biofortified compost was calculated. Also, 57% and 41% of waste mass reduction was observed by *Trichoderma* sp degraded biofortified compost and *Fusarium* sp degraded biofortified compost, respectively. Though, only 0.1% of decrease in waste mass was calculated in control groups. The odour of compost was woody earthy and the color was blackish brown.

**Estimation of chemical analysis of compost**

In the process of composting the end product was analyzed and the percentage of micro and macro nutrients was estimated. This analysis revealed the presence of all Kinds of essential primary, secondary and trace elements with increased proportions.

**DISCUSSION**

The chicken feather degradation capacity of keratinolytic fungi into biofortified compost were tested. This study clearly showed that microbial degradation is eco-friendly and the most cost effective technique. *Aspergillus* sp showed maximum degradation that was about 73%. *Trichoderma* sp degraded 57% and *Fusarium* sp degraded 41% of chicken feathers. The keratinolytic fungi was isolated in this study could play an important role in production of animal feed protein in addition to the biodegradation of poultry wastes for betterment of environmental hazards. Feather waste is generated in large amounts as a by-product of commercial poultry processing. Disposal of this waste is accounting in soil pollution and burning of this waste releases sulfur dioxide. From this work, *Aspergillus* sp can be recommended for feather degradation. The keratinophilic fungi play an important ecological role in the biodegradation of keratin substrates and can help in the environment protection. Our study provides useful platform related to microbial degradation of keratin. According to our results, the *Aspergillus* strain showed good biodegradative activity. The strain could be used as an economical and environmentally safe method of recycling there organic materials into high nitrogen fertilizer.

**CONCLUSION**

Keratinophilic fungi are ecologically an important group of fungi which could be found in soil. Some groups of these fungi are causative agents of cutaneous fungal infections named dermatophytosis, and the other saprophyte fungi mainly represent hyphomycosis (Palsson, 1968). The prevalence of these fungi depends on different factors, such as the presence of creatinine in the soil, pH, and geographical location, In this present study was conclude that *Aspergillus* sp has high chicken feather degrading capacity and compost is suggested for use of organic fertilizer to increase the plant growth and yield than chemical fertilizer. Further studies

can be focused on whether consortium can be utilized for feather degradation, rather than individual cultures for enhanced keratinolytic activity.

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**Table 1:Physicochemical Parameters of Soil Sample**

S.No	Physicochemical parameters	Before treatment
1.	pH	6.2
2.	Temperature (°C)	7.4
3.	Moisture %	62
4.	Electrical conductivity(mS)	1.20 - 1.80
5.	Nitrogen (mg)	86.4
6.	Phosphorus (mg)	80.2
7.	Potassium(mg)	38
8.	Carbon(mg)	0.78

**Table-2 chemical properties of biofortified compost**

Parameter	Fungal species		
	<i>Aspergillus</i> sp	<i>Trichoderma</i> sp	<i>Fusarium</i> sp
Total N (%)	6.84	5.32	3.21
Total C (%)	42.34	39.23	30.34
C/N Ratio	6.23	5.23	3.54
Calcium (ppm)	4028	3254	2365
Phosphorous (ppm)	5.99	4.32	2.43
Iron (ppm)	3.43	2.12	1.22
Copper(ppm)	Nil	Nil	Nil
Zinc (ppm)	<0.1	<0.1	<0.001
Magnesium (ppm)	0.006	0.004	0.001
Sulphate (ppm)	0.078	0.052	0.043





**Kannahi and Lakshmipriya**

<p><b>Figure 1 : Effect of pH on compost following periodic incubation of 10 days</b></p>	<p><b>Figure 2: Effect of temperature on compost following periodic incubation of 10 days</b></p>
<p><b>Figure 3:Electrical conductivity changes in post culture medium following periodicincubation of 10 days</b></p>	<p><b>Figure 4: Reduction of moisture content (%) in post culture medium following periodicincubation of 10 days</b></p>
<p><b>Figure 5: Reduction of organic matter (%) in post culture medium followingperiodic incubation of 10 days</b></p>	





## Review on Perspectives of Childhood Disorders in Developmental Stages and Treatment in Traditional Siddha System of Medicine

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### ABSTRACT

Traditional siddha system of medicine has been used for centuries to treat various diseases and conditions which can help promote their overall health and well-being. Prevalence of Childhood disorders are common and can affect a significant proportion of the population. *Paruvangal* (stages of development) combines the motor, psychological and social development of the child and links to disorders specific to those stages. These practices can provide a strong foundation for healthy, physical and psychological functioning throughout their life. It includes Herbal treatments for respiratory disorders (*Kanam*), digestive issues(*Maantham*), skin problems (*Karappan*), *Suram and Sanni* (Fever and Infections), *Kazhichal and Vallipu* (Malnutrition and Weakness) from early infancy to late childhood. This study can help us identify effective strategies and address disparities in access to quality child care, and ensure that all children have access to the support which can help promote their overall health and well-being. Developmental context plays a crucial role in shaping a child's cognitive, social, emotional, and physical development.

**Keywords:** Childhood; *Paruvangal*; healthy children; utmost attention; ancient Siddha classics.





Preetheekha et al.,

## INTRODUCTION

Childhood disorders are a common health issue worldwide, affecting millions of children each year. Understanding these contextual factors is important for promoting healthy development and providing appropriate support for children who may be at risk for developmental delays or difficulties [1][2]. The World Health Organization (WHO) recognizes the importance of child care in promoting the health and well-being of children [3]. *Balavagadamis* is a term used in Siddha medicine to refer to the health and well-being of children [4]. It encompasses the physical, mental, and emotional aspects of a child's development and emphasizes the importance of maintaining a healthy balance between them and also offers treatments for a range of diseases and disorders that can affect children which include Respiratory infections: Digestive disorders: Skin diseases: Fever: Developmental disorders: Nutritional deficiencies: So studies about childhood disorders is important to better understand the prevalence, early warning signs, impact on families, and burden on the health care system[5]. Early intervention is often critical in managing childhood disorders. The aim of this study is to categories childhood diseases in Siddha and their treatment are mentioned based on stages of development of child (*Paruvangal*) which can identify early warning signs and develop interventions that can help children and their families [6].

### STAGES OF DEVELOPMENT(PARUVANGAL):

The word *Paruvams* emphasizes a holistic approach to child care that takes into account the developmental context of the child. This approach recognizes that children have unique needs and developmental stages, and that their physical, emotional, and psychological well-being are interconnected. *Kappu* (Protection stage), *Senkeerai* (Tender stage), *Thaalam* (Tongue movement stage), *Sappani* (Clapping stage), *Mutham* (Kissing stage), *Varugai* (Walking stage), *Ambuli* (Moonstage), *Chitril* (Playing with Mud house), *Siruparai* (Playing or beating drums) and *Siruthaer* (Riding toy vehicles stage) are the 10 stages of child development (*paruvangal*) mentioned. The development stages described in the *paruvams* are at the core of developmental psychology. Much of the contemporary research on play suggests it to be the major activity to promote healthy overall development. [7]. The *paruvams* go beyond it and suggests that the play, interaction and communication with the caretaker as the key to enhanced development.

### THERAPEUTIC CONTRIBUTION

The Siddha system of medicine combining developmental stages and disorders that occur in each of these stages is an extraordinary clinical practice. It is given in the table1.

### COMMON INFANTILE PROBLEMS AND TREATMENT:

#### STOMACH UPSETS

Indigestion is the main problem up to one year of age. These are prevented by maintaining a hygienic environment for the child and the personal hygiene of the mother and child. Timely feeds too are very important. A late feed can lead to hunger and over feeding would end in indigestion.

1. Garlic fried with Ajowan (*omam*) is the ideal treatment. *Seeragachooranam* (cumin) can be given in honey. [10]
2. Take 10 betel leaves. Apply little slacked lime on it. Cut the leaves into small pieces slightly fry it. Pour 200ml water. Allow it to boil till it is reduced to 25ml. Filter the above decoction and give one teaspoon to the baby to take it orally. [12] If the baby has vomiting and bloating stomach and is found yawning:

In such conditions the following medicines are administered to the baby: [12]

1. Take 5 grams of jequity (*athimathuram*) and grind it well by applying some rice washed water. Apply this paste on the abdomen region. It will eliminate the bloating stomach.
2. Take 5 grams of Garlic and 5 gms of Ajowan (*omam*) and fry it well. Prepare decoction to the baby to take orally three times. The vomiting will go.
3. Grind a small piece of jequity (*athimathuram*) with a few drops of cow's milk. The paste may be taken and applied on the mother's breast. Now the child would start with mulching willingly. [13]





Preetheekha et al.,

### Chronic vomiting:

Take 25 ml of lime juice and add little sugar. Add 15 number of Coriander sativum (*Kothumalli*) to make fine powder and mix it with the above mixture. Filter and give a spoon to the child to take orally.

**GRANTHI:[10]** Grind the Hoptage Madalette (*Karudakodiver*) with a few drops of hot water and mix it with hot water and give a teaspoon it to the baby orally

1. Collect the tender leaves of Indian coral tree (*mullumurungai*), Sensitive/humble plant (*Thottalvaadi*) and onion (*Ulli*) in equal small quantity against each. Crush then, take juice and mix it with *GoroChanam* (bile of cow) of 2 mgs and give a teaspoon it to the baby orally
2. Equal quantity of ghee, castor oil and gingelly oil (*Mukkuttune*) are mixed with *Sangam* (*sangamkuppi*) leaf juice and water ground paste of *Chukku* and *thippili* added to the mixture, which is then kept in the sun till the water content evaporates. The residual *neis* administered to the baby at 500mg at morning for three days

### Bath

The above Ghee is applied all over the body of the baby, after which bath is given in warm water containing the infusions of *semmulli* (*Barlieriaprionitis*) and *granthinayagam* (*Hygrophila auriculata*)

1. *Onan's* (oriental garden lizard) blood with donkey's milk penny weight is an effective remedy for *Karungiranthi*.
2. Collect the leaves of *Jequirity* (*Vellaikuntrielai*), onion and leaves of Holy basil (*Tulasielai*) in equal quantity against each. Crush them to collect juice in a teaspoon. Grind a bit of *GoroChanam* by adding a few drops of the above juice and give it to the baby orally.
3. The tablet called '*Kumara sanjeevaimathirai*' shall be made paste by adding a few drops of breast milk. Then mix more mother's breast milk and give a spoon to the baby to take orally. **Preparation:** Take *Saathravedi* (*Sathrabethi*), *Jequirity* (*Athimathuram*), The round white *Zedoary tree* (*poolavirutcham*), *China Root* (*Cheenappaovu*) and black *Zizphyus Rugosus Bark* (*Karunchoorapattai*) each weighing 10 grams and triturate the above items. Again collect *Kurrooa* (*Kadugu Rogini*), *GoroChanam* weighing 5 grams each. Grind both the groups of powder/drugs by applying donkey's milk to make fine paste i.e. waxy form. Convert them into small balls similar to pepper size. Allow it to dry in shadow (Not sunlight). Now collect and keep them in a bottle. While the baby is on above medication, the mother should avoid taking tamarind, salt and mutton.

### PIRALINOY:[13]

1. A hand full of *trellis-vine* (*Velliparuthielai*) is taken and crushed to make juice. Add a bit of rock salt (*Induppu*) with it. Give a tea spoon to the baby in woman's breast milk to take orally.
2. Take 2 leaves of *betel* (*Nagavallielai*). Apply coconut oil on its sides, show one side of the leaves on flame and place the leaves on abdomen of the baby.

### THODAM

Tantrik practices were commonly carried out, traditionally using *keezhanellikulisam* [14] Thodam concept reveals an extraordinary attention to cleanliness of the infant and disorders acquired through contagion. Pill prepared from *Jequirity* (*Athimathuram*), *Treemanjal* (*Mara manjal*), *Nutgrass root* (*Koraikizhangu*), *Indianatees* (*Athividayam*), *Sweet flag* (*Vasambu*), *Skin of Ink nut* (*Kadukkaihole*) and *Himalayan Cedar* (*Deva dharam*). One pill in breast milk twice a day for 5 days. [14]

### Preparation

*Jequirity* (*Athimathuram*), *Tree manjal* (*Mara manjal*), *Nutgrass root* (*Koraikizhangu*), *Indianatees* (*Athividayam*), *Sweet flag* (*Vasambu*), *Skin of Ink nut* (*Kadukkaihole*) and *Himalayan Cedar* (*Deva dharam*), *Dried Ginger* (*Chukku*), *Root of Daemia* (*Velliparuthiver*), *Beetle killer* (*Siruthyekku*), *Hellbore* (*Kadugyrohini*) each weighing 5 grams. Grind them with juice of *Phylla* (*poduthallai*) and *Daemia* (*Velliparuthi*) each of 25 ml. when it comes to waxy consistency, convert them into pills of size of pepper. Have it dried up under the shade. If the child has diarrhea one pill is given with







**Preetheekha et al.,**

Ajowan(*omam*) and long pepper (*Thippili*) each weighing 5 grams. If the child has constipation one pill is given in ginger juice. For fever one pill is given in decoction of galangal(*Chitharathai*).

**MANTHAM: [13]**

1. Collect Sweet flag(*Vasambu*), Valerian root(*Chandamanji*), Dried ginger, pepper, Long pepper(*Thippili*), Black cumin(*Karunjeeraham*) each of 5 grams, crush them and prepare decoction. Give one spoon to the baby to take orally in the morning and evening.

**Kadukkaithailam: [14]**

Bring Bark of Chebulic (*KadukkaiThole*), the round zeodary (*KasthuriManjal*) and Bryoms Root (*KarudanKizhangu*), weighing 18 grams each, and grind them well each separately. The above powder may be mixed with 1.2 litre of gingelly oil in a vessel. Boil it over an oven till it comes to sand consistency (*ManalParuvam*) and unload it. Decant it in a bottle, when it cools down. Give this Oil 600 mg in woman's breast milk in the morning and evening. Mother should observe diet restriction. If the baby suffers from *Mandha* fever *kadukkaithylam* is given.

**Premi Nei : [15]**

There is another medicated ghee namely PremiNei, which is good for the baby, suffering from *Mandham*. Collect the 1.3 litre juice against each of Daemia (*VeliparuthiCharu*), Vidathai Charu, White dead Nettle (*ThumbaiCharu*), Drum Stick Tree leaf (MurungaiElaiCharu), Acalypha fruticosa (*ChinniElaiCharu*), Bitter Gourd (PakalelaiCharu), Bitter Phyla (*PoduthalaiCharu*) and Onion (Venkaya Charu). Again Neem Oil (*VeppaEnnai*) and (AmanakkuEnnai) each measuring 0.3 litre may be taken. Both the above may be mixed up in a vessel and place it over an oven to boil. Further take Garlic (Poondu), Sweet Flag (*Vasambu*) Ajowan (*Omam*), Dried Gin runkayan) and Rock salt (*induppu*), and grind them well. Ginger (*Chukku*), Asafoetida (*Perungayam*) each weighing 25 grams. Sprinkle the above powder in the boiling mixture. Boil till it reaches waxy consistency. Unload and allow the ghee to cool down. Filter and preserve the ghee in an air tight jar. Give a small tea-spoon of this ghee in ginger juice, if the baby is required to pass motion. If the diarrhoea is to be Stopped, the same ghee is to be administered in the decoction prepared from the fried Ajowan (*Omam*) and sweet flag (*Vasambu*).

**KARAPPAN(ECZEMA):**

1 Take IndigoferaEnneathylla(*SemponNerunji*), Bark of black zizphyus rugosus(Karunjeeragattai) and Bark of the Portia tree(*Poovarasampattai*) and prepare decoction. Give a tea spoon mixed with 500mg of *Gorochanam* orally.

2. *Sembarathi ennai*: Take the juice of Red cotton (*SembarathiCharu*) 0.3 litre, Coconut oil 1.3 litre and castor oil 150ml. Mix all together along Dried Ginger, Cardomum, Cloves, Long pepper and Camphor each weighing 5gms, duly powdered. The mixture is boiled and filtered.

The child may be given 5 drops of this oil and applied on the skin. The baby is given warm water bath after half-an-hour. This medicine is good for *Soolai*, *Granthi*, *Karappan* etc.

3. *Kuzhambu*: Take *ThiruvathiElai* and coconut kernel scraping(*Thengaithiruval*) fry them in a pan. When it turns reddish, bit of opium is added and grinded well as a paste. This is applied over the Eczema lesions.

**CHORI/SIRANGU(SCABIES AND ITCHES): [14]**

Coconut oil and juice of heart wood bark(*Poovarasampattai*) each weighing 0.6 litres is taken and mixed with Black cumin (*Karunjeeragam*) Babchi seed(*Karkolarisi*), Vembadal, Sulphate(*Thuttam*) and copper acetate(*Thurusu*) each weighing 5 grams is taken. Powder the drugs and mix it with other items in the vessel. Boil until it becomes sand consistency filter and decant the oil in a bottle. The oil is applied on scabies and itches. Take coconut oil and juice of Drumstick leaf(*Murungaielaicahru*) each of 0.5 litres. Again collect Black cumin(*Karunjeeragam*) and common salt weighing 10 grams each and powder them. Mix both the groups of items together in a vessel. Boil until it becomes sand consistency filter and decant the oil in a bottle. The oil is applied on scabies and itches.





Preetheekha et al.,

#### **Pei chori(Rashes): [13]**

The child may get rashes in the skin. As a result of the pain, child would suffer. This occurs owing to body heat or worms. Take 200ml of cow's ghee. Powder 5 grams of Rock salt (*Induppu*) and mix it with the ghee in a wide mouthed vessel. Keep it in hot sun for few hours. Repeat it for two more days. This may be applied on rashes.

#### **ACHARAM(ULCER IN THE MOUTH):**

Take few numbers of magic nut(*Mayakai*) and grind them well with a few drops of woman's breast milk and apply a little paste on the mouth of the baby.

Collect the froth of the coconut oil taken from grinding milk (*Chekku*) and apply on the ulcers.

Small tender coconut (Size of lime fruit) may be crushed and juice is collected. Apply a few drops of juice on the mouth.

## **DISCUSSION**

Emerging diseases, such as *Thodam*, have found their place in the annals of Siddha medicine, a tradition deeply rooted in history. Siddha medicine, known for its cost-effective and easily obtainable treatments, has documented numerous remedies for these conditions. Ancient Siddha texts provide insights into various single and combined drug medications. Notably, magnets, which possess positive and negative poles akin to the cells in our blood, are utilized to enhance blood circulation through the attraction of opposite poles. This streamlined circulation often leads to the alleviation of illnesses, leaving individuals feeling rejuvenated. The evolution of Siddha pharmaceuticals becomes apparent when we consider properties like palatability, digestibility, and enhanced bioavailability. These attributes have likely driven the development of medicinal formulations. In the contemporary era, where herbal resources are sometimes scarce, the imperative to craft child-friendly formulations with minimal drugs without compromising quality arises. Additionally, treating children presents unique challenges, necessitating innovative approaches, especially when conventional methods like *Vamana* (emesis) and *Nasya* (nasal drops) are contraindicated for pediatric patients[14]. Through astute observations and trials of that era, Siddha practitioners identified drugs capable of indirectly addressing pathology, ensuring the well-being of young patients. Siddha medicine, with its enduring wisdom, bridges the gap between ancient traditions and modern healthcare needs, emphasizing accessible treatments, innovative pharmaceuticals, and tailored care for children.

## **CONCLUSION**

Historical research underscores that efforts to standardize *Vaidya* education inadvertently delegitimized myriad regional Vaidya practices rooted in diverse vernacular texts, thereby undermining their significance. This knowledge can help to develop strategies to prevent, manage, and support children and families affected by these disorders.

The classification of diseases from birth to childhood according to *paruvangal* and description of various lines of treatment with specific herbs, is a distinct feature of paediatric medicine in siddha. Overall, traditional systems of medicine emphasize the importance of gentle and natural practices caring for babies, which can help promote their overall health and well-being. Child care in Siddha system of medicine plays a critical role in supporting children's growth, learning, and development. It is also an essential tool for helping parents to balance work and family life, and it can be a powerful tool for promoting social equity and inclusion.

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Table 1: Disorders in Developmental stages of child

Paruvangal	Diseases
Kaappuparuvam(Birth- 3 months)	<i>Granthi</i> : [8] This is an inherited condition with blisters of red and black variety all over the body (possibly epidermal bullosa) along with some nonspecific symptoms.
	<i>Piralinoy</i> :The sign is that the stomach and abdomen are twisted in such a way that the baby have stomach-ache and bloating stomach.The baby is found crying, motion may pass in green colour.
<i>Senkeeraiparuvam</i> (3-6 mon) <i>Thaalaparuvam</i> (6-9 mon) <i>Sappaniparuvam</i> (9-12 mon) <i>Muthaparuvam</i> (12-15 mon)	<i>Thodam</i> : [9] [10] The term thodam means touch and the sources of the touch are least to say, are intriguing. Thodam are due to big, medium-sized or small birds or evil spirits. Symptoms are dysentery and diarrhea along with dehydration.





## Preetheekha et al.,

<p><i>Varugaiparuvam</i> (15-18 mon)</p> <p><i>Ambuliparuvam</i>(1 ½-2 years)</p>	<p><i>Maantham</i>: [10]</p> <p><i>Maantham</i> is a group of gastrointestinal disturbances caused by digestive disorders due to poor assimilation and absorption of intake. The baby's stomach would be found bloated, High temperature. The baby would look like an owl. The food would not be digested. <i>Paalmatham</i> may be lactose intolerance.</p>
<p><i>Sitrilparuvam</i>(2-2 ½ years)</p> <p><i>Sirukeeraiparuvam</i>(2 ½-3 years)</p>	<p><i>Karappan</i>: [11]</p> <p>Eruptions spreading over any part of the body in clusters of light coloured papules each of the size of a mustard seed.It terminates in loose yellowish or brown scabs.</p>
<p><i>Siruthaerparuvam</i>(2 ½-3 years)</p>	<p><i>Ganam</i>: [11]</p> <p><i>Ganam</i> represents a group of respiratory disorders.Symptoms range from soreness and discolouration of the tongue, cough, fever, structure of ribs (suggestive of rickets). <i>Maantham</i>precipitates <i>Ganam</i></p> <p><i>Acharam</i>: [10]</p> <p>Small white ulcers or vesicles in mouth,lips and the tongue arising from the disordered state of the stomach. It chiefly affects children.</p>





## Analysis of A Markovian Retrial Queue with Working Vacation and Vacation Interruption Under Bernoulli Schedule

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### ABSTRACT

In this article, we analyze a Markovian retrial queue with working vacation and vacation interruption under Bernoulli schedule. In this model, all service times, retrial times and vacation times are assumed to have an exponential distribution. In the working vacation, a customer is served at lower speed, and if there are customers in the orbit at the instant of a service completion, the server is resumed a regular busy period with probability  $p$  (i.e., the vacation is interrupted) or continues the vacation with probability  $1-p$ . We obtain the probability generating function for the number of customers in the system. We also compute the average number of customers and waiting time in the system. Some of the special cases are discussed. Finally, numerical examples are illustrated.

**Keywords:** Retrial Queue, Working Vacation, Vacation Interruption, Bernoulli schedule.

### INTRODUCTION

Retrial queueing systems are expressed by the arriving customers who find the server busy, leaves the system and join the orbit to repeat their request for service after some random amount of time such a queueing models can be seen in many real life problems in web access, telecommunication networks, banking sector and computer systems etc. Recently many authors widely discussing about retrial queue. For more details, we can refer in the survey paper T.Yang and J.G.C.Templeton [19] and G.I.Falin [5]. In queueing system, vacation and retrial queueing systems with working vacations has been discussed in the recent past. L.Servi and S.Finn, [13] introduced M/M/1 queue with working vacations (M/M/1/WV), the server provides service at a lower speed during the normal service period





**Pazhani Bala Murugan and Chitra**

without stopping service completely. In later Aissani, A., Taleb,S., Kernane,T., Saidi,G., and Hamadouche,D (2014) generalized the model to an (M/G/1) queue. Wu and Takagi [4] discussed the concept of *M/G/1/MWV*. Kalyanaraman and Pazhani Bala Murugan [17] have developed the retrial queue with vacation, Pazhani Bala Murugan and Santhi[18] studied the *M/G/1* retrial queue with *MWV*. For a comprehensive study on WV we can refer [21]. As use the sever effectively, working vacation interruption introduced by Li and Tian (2007). During a working vacation period, the server finds if there are customer in the system at a service completion instant,the vacation either is interrupted with probability  $p(0 \leq p \leq 1)$  or continues with probability  $q(p + q = 1)$  analyzed by Zhang and Shi(2009) *M/M1* queue with Bernoulli working vacation interruption. In this article, we consider analysis of a Markovian retrial queue with working vacation and vacation interruption under Bernoulli schedule . This article has the following structure. This paper explained as follows segment 2 gives a model description. In segment 3 performance measures are distinguished.In segment 4 numerical outcomes are revealed. The conclusion is given in segment 5.

**MODEL DESCRIPTION**

We examine analysis of a Markovian retrial queue with working vacation and vacation interruption under Bernoulli schedule. We consider the customers arrival follows a Poison process with arrival rate  $\lambda$ . The service time of the server served the customers is on an FCFS basis with exponentially distributed. The inter arrival time follows the exponential distribution with rate  $\alpha$  respectively. The vacation time follows exponentially distributed with parameter  $\theta$  respectively. The service time during a working vacation time follows with rate  $\eta$  respectively. The service time during a normal busy period follows with rate  $\mu$  respectively. The service time during a working vacation period, the server finds if there are customer in the system at a service completion instant,the vacation either is interrupted with probability  $p(0 \leq p \leq 1)$  or continues with probability  $q(p + q = 1)$  respectively. We assumed that inter- arrival times, service time, working vacation times are consider to be mutually independent. Let  $O(t)$  be the Size of the

system at  $t$ . At time  $t$  the four distinct states of the server are  $Y(t) = \begin{cases} 0 & \text{if the server is not occupied in WV} \\ 1 & \text{if the server is occupied in WV} \\ 2 & \text{if the server is not occupied in RS period} \\ 3 & \text{if the server is occupied in RS period} \end{cases}$

We obtain the following steady state equation is

$$(\lambda)P_{0,0} = q\eta P_{1,0} + \mu P_{3,0} \tag{1}$$

$$(\lambda + \alpha + \theta)P_{0,n} = q\eta P_{1,n}; \quad n \geq 1 \tag{2}$$

$$(\lambda + q\eta + \theta)P_{1,0} = \lambda P_{0,0} + \alpha P_{0,1} \tag{3}$$

$$(\lambda + \eta + \theta)P_{1,n} = \lambda P_{0,n} + \alpha P_{0,n+1} + \lambda P_{1,n-1}; \quad n \geq 1 \tag{4}$$

$$(\lambda + \alpha)P_{2,n} = \mu P_{3,n} + \rho \lambda P_{1,n} + \theta P_{0,n}; \quad n \geq 1 \tag{5}$$

$$(\lambda + \mu)P_{3,0} = \alpha P_{2,1} + \theta P_{1,0} \tag{6}$$

$$(\lambda + \mu)P_{3,n} = \lambda P_{2,n} + \alpha P_{2,n+1} + \theta P_{1,n} + \lambda P_{3,n-1}; \quad n \geq 1 \tag{7}$$

To solve the equations (1 – 7), We define the following probability generating function

$$P_0(z) = \sum_{n=1}^{\infty} P_{0,n} z^n \quad P_1^*(z) = \sum_{n=0}^{\infty} P_{1,n} z^n$$

$$P_2^*(z) = \sum_{n=1}^{\infty} P_{2,n} z^n \quad P_3(z) = \sum_{n=0}^{\infty} P_{3,n} z^n$$

We multiply both sides of equation (2) by  $z^n$  and summing over  $n$  from 1 to  $\infty$  we have,

$$(\lambda + \alpha + \theta)P_0(z) = q\eta P_1(z) - q\eta P_{1,0} \tag{8}$$







**Pazhani Bala Murugan and Chitra**

Next multiplying equation (4) by  $z^n$  and summing over  $n$  from 1 to  $\infty$  and adding equation (3), we have  $(\lambda - \lambda z + \eta + \theta)zP_1(z) = \lambda zP_{0,0} + (\lambda z + \alpha)P_0(z) + p\eta zP_{1,0}$  (9)

Like similar, we multiply both sides of equation (5) by  $z^n$  and summing over  $n$  from 1 to  $\infty$  we have,  $(\lambda + \alpha)P_2(z) = \mu_3 P_3(z) + p\eta P_1(z) + \theta P_0(z) - [\mu P_{3,0} + p\eta P_{1,0}]$  (10)

Multiplying equation (7) by  $z^n$  and summing over  $n$  from 1 to  $\infty$  and adding equation (6), we have  $(\lambda - \lambda z + \mu)zP_3(z) = (\lambda z + \alpha)P_2(z) + \theta zP_1(z)$  (11)

Solving (8), (9), (10), (11) equations by using crammer’s Rule

$$\begin{aligned} (\lambda + \alpha + \theta)P_0(z) - q\eta P_1(z) + 0 \cdot P_2(z) + 0 \cdot P_3(z) &= -q\eta P_{1,0} - (\lambda z + \alpha)P_0(z) \\ +(\lambda - \lambda z + \eta + \theta)zP_1(z) + 0 \cdot P_2(z) + 0 \cdot P_3(z) &= \lambda zP_{0,0} + p\eta zP_{1,0} \\ -\theta P_0(z) - p\eta P_1(z) + (\lambda + \alpha)P_2(z) - \mu P_3(z) &= -\mu P_{3,0} - p\eta P_{1,0} \\ -\theta P_0(z) - \theta zP_1(z) - (\lambda z + \alpha)P_2(z) + (\lambda - \lambda z + \mu)zP_3(z) &= 0 \end{aligned}$$

We have  $\Delta = [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][\lambda(\lambda + \alpha)z - \alpha\mu][1 - z]$

$$\begin{aligned} \Delta_0 &= [(\lambda + \alpha)(\lambda - \lambda z + \mu)z - (\lambda z + \alpha)\mu][ -q\eta P_{1,0}(\lambda - \lambda z + \eta + \theta)z + \\ &\quad q\eta(\lambda z P_{0,0} + p\eta z P_{1,0}) \\ P_0(z) = \frac{\Delta_0}{\Delta} &= \frac{-q\eta P_{1,0}(\lambda - \lambda z + \eta + \theta)z + q\eta \lambda z P_{0,0} + q\eta p\eta z P_{1,0}}{[(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)]} \end{aligned} \tag{12}$$

Let  $f(z) = (\lambda + \alpha + \theta)(\lambda - \lambda z) + \eta + \theta)z - q\eta(\lambda z + \alpha)$  for  $f(z) = 0$  we obtain

$$\begin{aligned} f(0) < 0 \text{ and } f(1) > 0 \text{ which } \Rightarrow \text{ that } \exists \text{ a real root } \gamma \in (0,1). \text{ At } z = \gamma(12) \text{ is converted in to } P_{1,0} = \frac{1}{(\lambda - \lambda\gamma + q\eta + \theta)} \lambda P_{0,0} \\ &= B(\gamma)\lambda P_{0,0} \end{aligned} \tag{13}$$

$$\text{From (1), } \mu P_{3,0} = (1 - q\eta B(\gamma))\lambda P_{0,0} \tag{14}$$

Sub (14), (15) in (12), we have

$$P_0(z) = q\eta \lambda P_{0,0} \frac{[z - zB(\gamma)(\lambda - \lambda z + q\eta + \theta)]}{[(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)]} \tag{15}$$

$$\begin{aligned} \Delta_1 &= \lambda P_{0,0} [(\lambda + \alpha + \theta)z(1 + p\eta B(\gamma)) - q\eta(\lambda z + \alpha)B(\gamma)] \\ &\times [(\lambda + \alpha)(\lambda - \lambda z + \mu)z - (\lambda z + \alpha)\mu] \end{aligned} \tag{16}$$

$$\begin{aligned} \Delta_2 &= \lambda P_{0,0} (1 - z) \{ (1 + p\eta B(\gamma)) [ -\lambda z(\lambda + \alpha + \theta)(\lambda - \lambda z + \mu + \theta) \\ &+ \lambda q\eta \alpha (1 - z) + q\eta \alpha \mu ] + q\eta B(\gamma) [ \lambda z(\lambda + \alpha)(\lambda - \lambda z + \mu + \theta + \eta) \\ &- \lambda \eta (\lambda z + \alpha) - \alpha \mu (\eta + \theta) ] \} \end{aligned} \tag{17}$$

$$\begin{aligned} \Delta_3 &= \lambda P_{0,0} (1 - z) \{ (1 + p\eta B(\gamma)) [ -z(\lambda + \alpha + \theta) [ \alpha \theta + \lambda(\lambda z + \alpha) ] \\ &+ q\eta \alpha (\lambda z + \alpha) ] + q\eta B(\gamma) (\lambda z + \alpha) [ \lambda(\lambda + \alpha)z - \eta \alpha ] \} \end{aligned} \tag{18}$$

$$P_1(z) = \frac{\Delta_1}{\Delta} = \lambda P_{0,0} \frac{[(\lambda + \alpha + \theta)z(1 + p\eta B(\gamma)) - q\eta(\lambda z + \alpha)B(\gamma)]}{[(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)]} \tag{19}$$

$$P_2(z) = \frac{\Delta_2}{\Delta} = \frac{[\lambda z P_{0,0} \{ (1 + p\eta B(\gamma)) [ -\lambda z(\lambda + \alpha + \theta)(\lambda - \lambda z + \mu + \theta) + \lambda q\eta \alpha (1 - z) + q\eta \alpha \mu ] + q\eta B(\gamma) [ \lambda z(\lambda + \alpha)(\lambda - \lambda z + \mu + \theta + \eta) - \lambda \eta (\lambda z + \alpha) - \alpha \mu (\eta + \theta) ] \}]}{[(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][\lambda(\lambda + \alpha)z - \alpha\mu]} \tag{20}$$

$$P_3(z) = \frac{\Delta_3}{\Delta} = \frac{[\lambda P_{0,0} \{ (1 + p\eta B(\gamma)) [ -z(\lambda + \alpha + \theta)(\alpha \theta + \lambda(\lambda z + \alpha)) + \alpha q\eta (\lambda z + \alpha) ] + q\eta B(\gamma) [ \lambda z(\lambda + \alpha)(\lambda(\lambda + \alpha)z - \eta \alpha) ] \}]}{[(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][\lambda(\lambda + \alpha)z - \alpha\mu]} \tag{21}$$





**Pazhani Bala Murugan and Chitra**

We define  $P(z) = P_{0,0} + P_0(z) + zP_1(z) + P_2(z) + zP_3(z)$  (22)

as the probability generating function of the number of customers in the system irrespective of the server state. We find  $P_{0,0}$ , by using normalization condition  $P(1) = 1$  Before finding  $P_{0,0}$ , we obtain by differentiating  $P_0(z), P_1(z), P_2(z), P_3(z)$ , we have

$$P'_0(z) = q\eta\lambda P_{0,0} \left( \frac{N_0(z)}{D_0(z)} \right)' \tag{23}$$

where  $N_0(z) = z - zB(\gamma)(\lambda - \lambda z + q\eta + \theta)$

$$N'_0(z) = 1 - B(\gamma)(\lambda - \lambda z + q\eta + \theta) + \lambda zB(\gamma)$$

$$D_0(z) = (\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)$$

$$D'_0(z) = (\lambda + \alpha + \theta)[-\lambda z + (\lambda - \lambda z + \eta + \theta)] - q\eta\lambda$$

when  $z = 1$  in (22) we have  $P'_0(1)$  the above equations becomes

$$N_0(1) = 1 - B(\gamma)(q\eta + \theta)$$

$$N'_0(1) = 1 - B(\gamma)(q\eta + \theta) + \lambda B(\gamma)$$

$$D_0(1) = (\lambda + \alpha + \theta)(\eta + \theta)z - q\eta(\lambda + \alpha)$$

$$D'_0(1) = (\lambda + \alpha + \theta)[-\lambda + \eta + \theta] - q\eta\lambda$$

Next, we have  $P'_1(z) = \lambda P_{0,0} \left( \frac{N_1(z)}{D_1(z)} \right)'$  (24)

where  $N_1(z) = (\lambda + \alpha + \theta)z(1 + p\eta B(\gamma)) - q\eta(\lambda z + \alpha)B(\gamma)$

$$N'_1(z) = (\lambda + \alpha + \theta)z(1 + p\eta B(\gamma)) - q\eta\lambda B(\gamma)$$

$$D_1(z) = (\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)$$

$$D'_1(z) = (\lambda + \alpha + \theta)[-\lambda z + (\lambda - \lambda z + \eta + \theta)] - q\eta\lambda$$

Similarly, when  $z = 1$  in (23) we have  $P'_1(1)$  the above equations becomes

$$N_1(1) = (\lambda + \alpha + \theta)(1 + p\eta B(\gamma)) - q\eta(\lambda + \alpha)B(\gamma)$$

$$N'_1(1) = (\lambda + \alpha + \theta)(1 + p\eta B(\gamma)) - q\eta\lambda B(\gamma)$$

$$D_1(1) = (\lambda + \alpha + \theta)(\eta + \theta)z - q\eta(\lambda + \alpha)$$

$$D'_1(1) = (\lambda + \alpha + \theta)[-\lambda + \eta + \theta] - q\eta\lambda$$

Next we have  $P'_2(z) = \lambda P_{0,0} \left( \frac{N_2(z)}{D_2(z)} \right)'$  (25)

where  $N_2(z) = ((1 + p\eta B(\gamma))[-\lambda z^2(\lambda + \alpha + \theta)(\lambda - \lambda z + \mu + \theta)$

$$- \lambda q\eta\alpha z(1 - z) + q\eta\alpha\mu z]) + q\eta B(\gamma)[\lambda z^2(\lambda + \alpha)$$

$$(\lambda - \lambda z + \mu + \theta + \eta) - \lambda\eta(\lambda z + \alpha)z - \alpha\mu(\eta + \theta)z]$$

$$N'_2(z) = (1 + p\eta B(\gamma))(-2\lambda z(\lambda + \alpha + \theta)(\lambda - \lambda z + \mu + \theta)$$

$$+ \lambda^2 z^2(\lambda + \alpha + \theta) - \lambda q\eta\alpha(1 - 2z) + q\eta\alpha\mu) + q\eta B(\gamma)(2\lambda z(\lambda + \alpha)$$

$$(\lambda - \lambda z + \mu + \theta + \eta) - \lambda^2 z^2(\lambda + \alpha) - \lambda\eta(\lambda + \alpha)z + \lambda z + \alpha)$$

$$- \alpha\mu(\eta + \theta))$$

$$D_2(z) = [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][(\lambda + \alpha)z - \alpha\mu]$$

$$D'_2(z) = [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta) - \lambda z(\lambda + \alpha + \theta) - q\eta\lambda]$$

$$+ [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][\lambda(\lambda + \alpha)]$$

when  $z = 1$  in (24) we have  $P'_2(1)$  from the above equations becomes

$$N_2(1) = (1 + p\eta B(\gamma))[-\lambda(\lambda + \alpha + \theta)(\mu + \theta) + q\eta\alpha\mu] + [\lambda(\lambda + \alpha) - \alpha\mu(\eta + \theta)]$$

$$N'_2(1) = (1 + p\eta B(\gamma))(-2\lambda(\lambda + \alpha + \theta)(\mu + \theta) + \lambda^2(\lambda + \alpha + \theta) + \lambda q\eta\alpha + q\eta\alpha\mu)$$

$$+ q\eta B(\gamma)(2\lambda(\lambda + \alpha)(\mu + \theta) - \lambda^2(\lambda + \alpha) - \alpha\mu(\eta + \theta))$$

$$D_2(1) = [(\lambda + \alpha + \theta)(\eta + \theta) - q\eta(\lambda + \alpha)][\lambda(\lambda + \alpha) - \alpha\mu]$$

$$D'_2(1) = [(\lambda + \alpha + \theta)(\eta + \theta) - \lambda(\lambda + \alpha + \theta) - q\eta\lambda][(\lambda(\lambda + \alpha) - \alpha\mu)]$$

$$+ (\lambda + \eta + \theta) - q\eta(\lambda + \alpha)][\lambda(\lambda + \alpha)]$$

$$P'_3(z) = \lambda P_{0,0} \left( \frac{N_3(z)}{D_3(z)} \right)' \tag{26}$$

where  $N_3(z) = ((1 + p\eta B(\gamma))[-z(\lambda + \alpha + \theta)(\alpha\theta + \lambda(\lambda z + \alpha)) + q\eta\alpha(\lambda z + \alpha)]$

$$+ q\eta B(\gamma)(\lambda z + \alpha)(\lambda(\lambda + \alpha)z - \alpha\eta)]$$

$$N'_3(z) = (1 + p\eta B(\gamma))[-(\lambda + \alpha + \theta)(\alpha\theta + \lambda(\lambda z + \alpha)) - z\lambda^2(\lambda + \alpha + \theta) + q\eta\alpha\lambda]$$

$$+ q\eta B(\gamma)[\lambda(\lambda(\lambda + \alpha)z - \eta\alpha) + (\lambda z + \alpha)\lambda(\lambda z + \alpha)]$$

$$D_3(z) = [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][(\lambda + \alpha)z - \alpha\mu]$$

$$D'_3(z) = [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta) - \lambda z(\lambda + \alpha + \theta) - q\eta\lambda]$$





**Pazhani Bala Murugan and Chitra**

$+\{(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)\}[\lambda(\lambda + \alpha)]$   
 when  $z = 1$  in (24) we have  $P'_3(1)$  from the above equations becomes  
 $N_3(1) = ((1 + p\eta B(\gamma))[-(\lambda + \alpha + \theta)(\alpha\theta + \lambda(\lambda + \alpha)) + q\eta\alpha(\lambda + \alpha)])$   
 $+q\eta B(\gamma)(\lambda + \alpha)(\lambda(\lambda + \alpha)z - \alpha\eta)$   
 $N'_3(1) = (1 + p\eta B(\gamma))[-(\lambda + \alpha + \theta)(\alpha\theta + \lambda(\lambda z + \alpha)) - z\lambda^2(\lambda + \alpha + \theta) + q\eta\alpha\lambda]$   
 $+q\eta B(\gamma)[\lambda(\lambda(\lambda + \alpha)z - \eta\alpha) + (\lambda z + \alpha)\lambda(\lambda z + \alpha)]$   
 $D_3(1) = [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][(\lambda + \alpha)z - \alpha\mu]$   
 $D'_3(1) = [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta) - \lambda z(\lambda + \alpha + \theta) - q\eta\lambda] + [(\lambda + \alpha + \theta)(\lambda - \lambda z + \eta + \theta)z - q\eta(\lambda z + \alpha)][\lambda(\lambda + \alpha)]$   
 We obtained by  $P_{0,0}$  by using normalization condition  $P_{0,0} + P_0(1) + P_1(1) + P_2(1) + P_3(1) = 1$

Which leads to,

$$P_{0,0} = \frac{1-\rho}{\left\{ \begin{aligned} &(\lambda(\lambda+\alpha)(\lambda+\alpha+\theta)(\eta-\mu)) - (\lambda+\alpha+\eta+\theta)\theta\alpha\mu - p\eta(\lambda+\alpha)\alpha\mu \\ &\alpha\mu[q\eta(\lambda+\alpha) - (\lambda+\alpha+\theta)(\eta+\theta)] \\ &- \left\{ \frac{p\eta B(\gamma)[(\lambda(\lambda+\alpha)(\lambda+\alpha+\theta)(\mu+\theta) - q\eta\lambda\alpha(\lambda+\alpha)]}{\alpha\mu[q\eta(\lambda+\alpha) - (\lambda+\alpha+\theta)(\eta+\theta)]} \right\} \\ &+ \left\{ \frac{p\eta B(\gamma)[\lambda(\lambda+\alpha)[\lambda q\eta + \eta\alpha - \mu(\lambda+\alpha)]}{\alpha\mu[q\eta(\lambda+\alpha) - (\lambda+\alpha+\theta)(\eta+\theta)]} \right\} \end{aligned} \right\}} \tag{27}$$

Where  $\rho = \frac{\lambda}{\mu} (1 + \frac{\lambda}{\alpha}) > 0 \Rightarrow \frac{\lambda}{\mu} (1 + \frac{\lambda}{\alpha}) < 11 - \rho > 0 \Rightarrow \rho < 1$  is the stability condition

**HE MODEL’S PERFORMANCE MEASURES**

Expected number of customers in the orbit when the server state is  $i = 0,1,2,3$

$$E(L) = P'_0(1) + P'_1(1) + P'_2(1) + P'_3(1) \tag{28}$$

**NUMERICAL AND GRAPHICAL RESULTS**

In this segment , we present some numerical results to study the expected number of customers in the orbit . We observe, the curved graph shows in Figure 2 and the values tabulated in the Table 1 are obtained by setting the fixed values  $\alpha = 3, \eta = 4, \mu = 10, \gamma = 0.4, p = 0.6, q = 0.4$  and varying the values of  $\lambda$  from 1 to 2 incremented with 0.2 and extending the values of  $\theta$  from 2 to 5 in steps of 1.5. We observed that as  $\lambda$  rises  $E(L)$  also rises which shows the stability of the model. The curved graph constructed in Figure 3 and the values tabulated in the Table 2 are obtained by setting the fixed values  $\alpha = 4, \theta = 2, \mu = 9, \gamma = 0.4, p = 0.6, q = 0.4$  and varying the values of  $\lambda$  from 1 to 2 incremented with 0.2 and extending the values of  $\eta$  from 3 to 6 in steps of 1.5. We observed that as  $\lambda$  rises  $E(L)$  also rises which shows the stability of the model. The curved graph constructed in Figure 4 and the values tabulated in the Table 3 are obtained by setting the fixed values  $\alpha = 4, \theta = 2, \mu = 9, \gamma = 0.4, p = 0.6, q = 0.4$  and varying the values of  $\lambda$  from 1 to 2 incremented with 0.2 and extending the values of  $\mu$  from 6.5 to 8.5 in steps of 1. We observed that as  $\lambda$  rises  $E(L)$  also rises which shows the stability of the model. The curved graph constructed in Figure 5 and the values tabulated in the Table 4 are obtained by setting the fixed values  $\theta = 2, \mu = 8.5, \eta = 9, \gamma = 0.4, p = 0.6, q = 0.4$  and varying the values of  $\lambda$  from 1 to 2 incremented with 0.2 and extending the values of  $\alpha$  from 4 to 6 in steps of 1. We observed that as  $\lambda$  rises  $E(L)$  also rises which shows the stability of the model.

**COCLUSION**

In this paper, an  $M/M/1$  retrial queue with working vacation and vacation interruption under Bernoulli schedule is evaluated. We obtain the PGF for the number of customers and the mean number of customers in the orbit. We also derive the performance measures. We perform some particular cases. We illustrate some numerical results.

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**Table 1:  $E(L)$  with turn over of  $\lambda$**

$\lambda$	$\theta = 2$	$\theta = 3.5$	$\theta = 5$
1.0	0.1539	0.1267	0.1110
1.2	0.2208	0.1842	0.1628
1.4	0.3010	0.2542	0.2265
1.6	0.3957	0.3380	0.3036
1.8	0.5069	0.4379	0.3965
2.0	0.6374	0.5569	0.5081

**Table 2:  $E(L)$  with turn over of  $\lambda$**

$\lambda$	$\eta = 3$	$\eta = 4.5$	$\eta = 6$
1.0	0.1595	0.1232	0.0994
1.2	0.2280	0.1780	0.1448
1.4	0.3096	0.2445	0.2007
1.6	0.4052	0.3241	0.2688
1.8	0.5165	0.4185	0.3510
2.0	0.6458	0.5305	0.4502





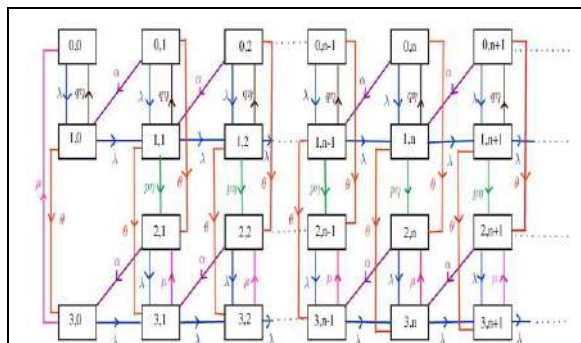
**Pazhani Bala Murugan and Chitra**

**Table 3:  $E(L)$  with turn over of  $\lambda$**

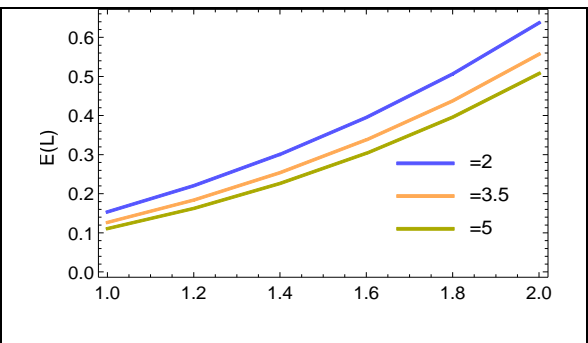
$\lambda$	$\mu = 6.5$	$\mu = 7.5$	$\mu = 8.5$
1.0	0.1885	0.1736	0.1634
1.2	0.2762	0.2512	0.2344
1.4	0.3857	0.3457	0.3195
1.6	0.5217	0.4597	0.4200
1.8	0.6913	0.5969	0.5381
2.0	0.9059	0.7629	0.6769

**Table 4:  $E(L)$  with turn over of  $\lambda$**

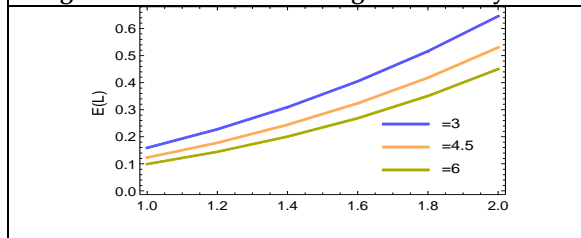
$\lambda$	$\alpha = 4$	$\alpha = 5$	$\alpha = 6$
1.0	0.1490	0.1316	0.1201
1.2	0.2147	0.1892	0.1723
1.4	0.2939	0.2582	0.2347
1.6	0.3882	0.3398	0.3080
1.8	0.4998	0.4355	0.3934
2.0	0.6319	0.5473	0.4925



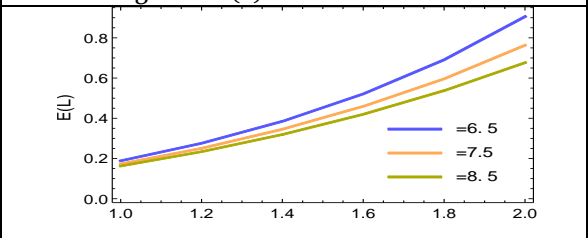
**Figure 1: Transition state diagram of the system**



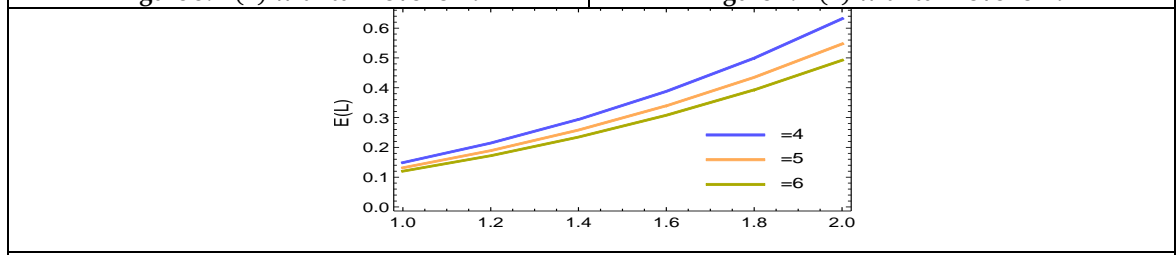
**Figure 2:  $E(L)$  with turn over of  $\lambda$**



**Figure 3:  $E(L)$  with turn over of  $\lambda$**



**Figure 4:  $E(L)$  with turn over of  $\lambda$**



**Figure 5:  $E(L)$  with turn over of  $\lambda$**





## Deconstructing Gender Expectations: A Scrutiny of *Udal's* Character sand Their Forced Gender Roles

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### ABSTRACT

This paper intends to explore the psychology of diverse characters in the debut movie *Udal: Love and Lust Inside*(2022) written and directed by Ratheesh Reghunandan and thereby systematically validate the conflicted gender edidentities. Flavouring this notion with the forced gender roles which later arouses violence and vengeance, the characters are subjected to scrutiny and it is palpable that the female character is enduring an intensified emotional and sexual frustration, making her cold enough to lash out her aggression. The objective of this paper is to identify the assigned role of gender in exposing them to commit a crime, switching off the humanity so as to save their name in the public and it makes the film dark and dense. The female characteris bound to experience an emotional turmoil, stemming from personal circumstances to societal pressures, the characteristic carried out tounveil her criminal instincts as the film progresses. Maintaining a dark tone, the film takes unexpected twists and turns making it a domestic crime thriller. Focus being laid on the female protagonist, this papers crutinizes the forced female responsibilities which she refuses to take up and that becomes the cause of darkness in the film. Conglomerating Social Role Theory and feminism, this 2022 film *Udal: Love and Lust Inside* investigates the nature and trajectory of each character and their visual sequences.

**Keywords:** Forced genderroles, feminism, social role theory, violence, gender stereotypes.





**Nina Ann Mathew**

## INTRODUCTION

The term gender has always been a conflicting topic for discussion and unlike any other subject, gender studies have become a universal code of communication. It is observed that, gender is a term attributed by the society to an individual in order to configure and install him to that society. Just like how the society shapes him, he then becomes the definition of what that society should look like. As a statement, gender becomes a slave to the forced stereotypes existing in that social order. Sex on one hand determines the biological attributes of a person where as gender is credited by the social norms. People under each sex are expected to behave in a way adhering to the standards of that social structure. Gender roles are born when the individual has to confabulate and interact with the environment and it is then that the society accepts him. Ann Oakley, a British sociologist and feminist who has made momentous contributions to the fields of gender and health has once stated that the concept of "gender roles," refers to the expectations and behaviors that are thought to be apposite for men and women in a particular society. Oakley has claimed that gender roles are disposed to be constructed socially and they can fluctuate greatly across cultures and time periods.

Gender demands us to occupy certain characteristics so as to build a name and identity in that society. Men and women are asked to act with ample disparities for them to be called a part of their environment. Today's practices and principles become tomorrow's stereotypes. Literature is the closest entity that clamors these binaries. Literature includes texts, films, music, art forms etc. of a specific nation and it reflects their socio-cultural elements. Literature acts like a vehicle in transporting ideologies that link the aspects of gender and its rules. In exploring gender roles, it's essential to consider the intersectionality of identities, acknowledging that gender intersects with other aspects such as race, class, ethnicity, sexual orientation, and abilities, resulting in diverse and unique experiences for individuals. Analysing gender roles requires a multidimensional approach, drawing on sociology, psychology, anthropology, and feminist theory to understand the complexities and implications of societal expectations related to gender. Understanding gender roles involves recognizing the complexities and diversity of human experiences related to gender. It also involves acknowledging that gender is not binary but exists on a spectrum, encompassing a range of identities beyond the traditional categories of male and female.

Gender roles are operated in a society with respect to the culture exercised there. Culture of a particular place has a crucial role in determining gender roles and its rules. Nations come into existence with the execution of culture. Every nation cultivates a culture that yields a national identity. Culture of a nation bears the definition that it "is the norms, behaviours, beliefs, customs, and values shared by the population of a sovereign nation. It refers to specific characteristics such as language, religion, ethnic and racial identity, cultural history and traditions" (Berrell). John Storey states that "Popular culture is mass produced commercial culture" (Storey). Popular culture as mentioned earlier is propagated through various social media platforms, music and most importantly the films of that era.

Movies are informal mediums for the dissemination of gender roles and it is easily decoded and deciphered by the audience. These moving pictures are mere reflections of a particular society and its cultural dimensions. Visual media such as films use moving images to tell a story and these recurring images create a perception in the audience's mind. Social psychologists suggest that these images often alter the way people perceive social realities and make contributions in shaping the audience's outlook, including their attitude towards topical social issues ("Gender Stereotypes in Malayalam Cinema")

Mollywood movies are extolled to have realistic illustrations of people in Kerala. Tracing the vestiges, it is evident that the roles of males and females are structured and concreted. Males who act like the head of the family take in charge of making money and they are coerced to have a definite and secure job. As they become the bread givers of their house, decision making gets completely vested in them. Whereas, the females in the family who are mothers, daughters and sisters, they are expected to remain inside the four walls, nurturing the family, cooking food and all the domestic chores are entrusted to them. They are supposed to caress and satisfy their tired and exhausted husbands,



**Nina Ann Mathew**

both mentally and physically. Emotions, with the passage of time and variation in circumstances, has acquired novel shapes and forms. Every day is an emotional battle that these women fight within themselves, and we are striving to plummet the negative impacts the novel situations have instilled in us. Literature in the form of texts as well as movies helps in the psychological development of a person.

*Udal: Love and Lust Inside* (2022) written and directed by Ratheesh Reghunandan is a visually stunning and emotionally resonating contribution to the Mollywood industry. This movie manifests the obligatory gender roles taken by each character and the friction caused by it becomes the plot of the film. The character shiny, played by Durga Krishna presents a single-handed show, competing with other characters like Kiran, played by Dhyan Sreenivasan and Kuttichayan played by Indrans. These characters are put under the pressures of personal conflicts and societal compressions. This paper tends to explore the aspect of gender roles in the above- mentioned film. A mansion like house with a Kerala style architecture is more than perfect as a setting to execute a story like this. As the movie was released in 2022, the director has not relegated the contextual elements of Covid-19 Pandemic and it plays an indiscernible character in the backdrop. The movie opens with the photograph of a married couple and then the focus is shifted to a packet of sanitary napkins kept on the table. It is not a common custom to expose sanitary napkins as it is considered as a taboo. Breaking the shackles of exclusion, female realities and forbidden frankness is brought in a single frame. The female character named Shiny is portrayed not as an ideal woman, but someone who is close to a slut as the society calls her. she is seen talking to a man over the phone and their conversation is more libidinous in nature. The scene starts with her, where she is trying to comfort her from the menstrual cramps by applying a hot water bag and parallelly she tries to convince him that she's on her periods. It is later only we understand that she was talking to her illicit lover or her paramour and their conversations are erotic in nature. The male character Kiran, considers her as a mere distraction or a rebound to gratify his sexual cravings.

Objectifying the female body of Shiny, he tells her that she is the most desirable and sexually attractive female of that locality as people in general talks about her. She admits the cantankerousness she feels when she's scrutinized by such jobless tale- tellers. To show off his adeptness in courting a married woman, he has even spilled the beans about this affair to his friends. It is evident that their relationship revolves around the sexual requirements of both Shiny and Kiran and they try to fill the void that has been created by their circumstances. A sudden transition is seen in her tone as she reflects on the realities of that house. She is shown as the mother of a 7-year-old boy and her husband is not seen in the picture until the end. Her mother-in-law is bedridden and has some serious ailment. The foul smell of faeces and the sickening scent of medicines dominate the air in house. Father-in-law who is half blind, is shown as a weak figure and he has a bedridden wife to take care of. Shiny had to quit her job in order to look after her sick parents whereas, her husband holds a reputed white-collar job and is away from home. She is forced to become a caretaker rather than excelling in a professional domain. Even though a home nurse is appointed to take care of her bedridden mother, the ultimate responsibility is vested in her. She seems to be alone in all these domestic domains and lacks the support and attention from her husband.

In such a scenario, women who is entrusted with the duty of being a mother, a caretaker and an ideal home maker, they tend to develop anxiety and depression. As they lack a personal space for happiness which incorporates her family, she might distract herself to keep her mental state stable. The International Journal of Indian Psychology states that, anxiety, frustration, anger and other psychological and emotional disturbances are leading forces that are causing chaos in the world leading conflicts among individual . These are the stressor force to the people bonded into the marital relation to choose the different paths (Trichal, 2021). Women especially in unhappy marriages tend to fall into mental illness making them weird and wild. When neglected, the feminine urge for individualism gets transmuted to some other forms of aggression and depression. This could be a pathway for both men and women to astray from their marital roles and they might find happiness which is vested outside of it. This could mark the beginning of an extra marital affair.



**Nina Ann Mathew**

As the movie progresses, Shiny is left with a mother to take care of. The home nurse leaves as she wishes to go back to her family. It is with great disgust that Shiny does this job. The saturation that she felt in doing this could be the aftermath of the lack of support and care from her husband. The duty of a husband is not to provide financially alone, but he is in charge of the emotional wellbeing of his family. The sex-typical roles offered by the society might put us under pressure and it might open up a different path. Shiny being the most frustrated soul in the film, she is in love with Kiran, who was a junior from college. The day the home nurse leaves the house, entrusting shiny to take care of the sick mother, shiny sends her son to her own house. This is a taken-for-granted opportunity for both Shiny and Kiran to meet that night. That night Kiran comes and they decide to make love. She considers Kiran as a shoulder to cry on. The movie now turns into a silent pace, but clamours the violent and criminal instincts in her. She makes plans to murder her sick, bedridden mother so as to emancipate herself from such a burden. She tells him that nobody would doubt if such a weak and indisposed person dies one fine morning. She suggests that it is better for her to die in order to bring peace in her life. Even though Kiran hesitates initially, later they commit the crime together. Shiny uses a wet towel to choke this mother to death. She then goes to the restroom and bursts into tears. As she is undergoing an emotional roller-coaster, we can see a rapid switching of roles in her. One moment she acts like a lover, a wife, a daughter and a mother with lovely attributes; but her mental state pushes her to unlock her fiendish behaviour. She tends to display her criminal instincts but again switches back to a female stuck with remorse and empathy.

Kiran did not want to commit such a crime as his conscience did not let him, but under Shiny's pressure he becomes voiceless and he is forced to do it. His past life or present relationship statuses are not updated in the movie but all we know about him is that he was Shiny's junior from college. As the movie proceeds, we understand that Kiran was not a terrible person. He finds pleasure in having an illegal relationship with Shiny, who is married to another man but not with criminal instincts. Sexual infidelity was defined by Leeker and Carozzi as "the occurrence of sexual involvement with a third party that violates the ground rules established by the couple (e.g., kissing, fondling, oral sex, vaginal sex, anal sex)". Emotional infidelity was seen as "the occurrence of emotional involvement with a third party that violates the ground rules established by the couple (e.g., trusting another, sharing your deepest thoughts with another, falling in love with another, being vulnerable with another, being more committed to another, spending more money on another), ("Love and Infidelity: Causes and Consequences"). Kiran and Shiny engage in both sexual and emotional infidelity. Shiny seems to have a mental breakdown because of her unhappy marriage and she finds comfort in Kiran.

Regichayan being a husband, he does not care for Shiny's emotional and mental well-being. All he cares about is his father, mother and his job. He forces her to be confined inside that four walls and asks her to fulfil her roles. He fails to give her the desirable attention or support. Even though this character has appeared only once that is in the climax scene, he is constantly heard by the audience over the phone. He is truly a good son, but a typical male chauvinist and a failed husband Kuttichayan, presented as a frail character initially, is also entrusted with gender roles. His love for his bedridden wife is a symbol of platonic love. At this age, he is ready to work hard and he never fails to look after his wife. In the first half of the film, he is portrayed as a father figure; nurturing, submissive and tolerant. But there is a sudden shift in the second half where he becomes a vengeful soul. He locks every possible door in that house so that Shiny and Kiran, who murdered his wife don't escape. His valour in the proceeding scenes are noteworthy. Being a Bollywood movie, a typical patriarchal society is an inevitable component. The division of labour for men and women is seen to have multiple disparities. Women who are asked to nurture and bear children are not wanted in a social and public realm whereas, men being the bread-givers of the family are asked to rule the house. Slight disruptions in this social gender order would be a feast for the jobless tale-tellers of that society. These norms raised by a group of people would later be engraved in the rule book of a society thus making it a cultural aspect.

As The social roles men and women play in a society are closely linked with the development of gender role beliefs. These beliefs prescribe how men and women should think, feel, and behave. People develop gender role beliefs as they observe male and female behaviour and infer that both sexes possess corresponding dispositions. These gender



**Nina Ann Mathew**

roles are thus internalized by people amidst complex socialization processes and they exhibit them in their own social roles. Gender stereotypes have a great role in shaping a person's character. This has a direct connection to his mental well-being too. We have ample scientific proof to make this statement stronger. Gender stereotypes can have a serious impact on gender and mental health. Women and gender minorities are particularly vulnerable to gender-related discrimination, which can exacerbate depression and lower self-esteem. It's been found that gender identity can shape people's experiences with depression ("How Do Gender Stereotypes Affect Mental Health?"). Shiny is a perfect example of a female identity who is confined to her gender roles. She had to sacrifice her profession as well as her other pleasure to look after that family. In the climax scenes it is seen that she loses her temper and bursts out her rage like a beast. He thrashes her father-in-law and bashes him to the ground. She lashes out her frustration and turns maniac. She portrays herself as brutal and merciless. Her identity and her attitudes towards this circumstance is questionable. When the situation goes wild, she loses her temper and her criminal dispositions are unveiled. A similar scenario happens to Kiran as well as Kuttichayan. According to Wood and Eagly (2010), gender roles operate vis-a-vis bio-social mechanisms that influence many aspects of behaviour. Wood and Eagly (2010) point out that people experience an activation of such biological processes in response to the sociocultural factors that guide feminine and masculine behaviours within cultures. *Udal: Love and Lust Inside* (2022) written and directed by Ratheesh Reghunandan is not an exception from a Mollywood movie that illustrates the pressures of gender roles. Deconstructing the gender stereotypes, the director has manifested his idea of forced gender roles and especially female frustrations. It is worthy to note the treatment given to male characters and female characters. The audience is with full enthusiasm to lambast the character Shiny who is portrayed more like a prostitute rather than understanding the issues faced by her. Towards the end of the film, we are able to comprehend that she had multiple relations like that she had with Kiran. Shiny being a female, maintaining an extra marital affair is considered to be a grave sin and this would bring her downfall. If this same marital affair was found in a male, it wouldn't have been a topic for a hot

**DISCUSSION**

Visual media, as a powerful form of storytelling and cultural expression, showcase a pivotal role in disseminating societal perceptions of gender roles. The silver screen serves as a mirror reflecting and, at times, challenging the traditional norms associated with masculinity and femininity. *Udal: Love and Lust Inside* (2022) is a perfect example which epitomizes the forced gender roles and cultural stereotypes prevailing in the setting of a Mollywood movie. Manifested with just three characters, the film runs on a dark mode and comes under the category of a domestic crime thriller. The audience is kept on a pin point but at the same time, they are forced to scrutinize the visual representations of each character. Shiny, the female character is forced to do certain chores which causes displeasure in her and her criminal instincts are unveiled. In this movie, cinematic masculinity and cinematic femininity are portrayed without any vagueness. One scene leading to another, the scenes get darker and the characters in the movie exhibit a lack of stability with their mental dispositions. This could be caused by the weight of gender roles assigned to them on their shoulders. Infidelity in marriage, unhappy lifestyles, sickness and melancholy, crushed female dreams, forced gender roles and a perfect violent crime are all blended together making it an embodiment of the Malayali-pandemic society

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## The Study on the Awareness Level of SDGs Goals Among Youth

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### ABSTRACT

The purpose of this study is to assess young knowledge of the Sustainable Development Goals (SDGs) and how important they are to sustainable development. Positive trends in youth knowledge and personal interest are revealed by the results of a survey conducted in the Ernakulam District of Kerala, with 50 respondents. However, a notable neutral stance on awareness suggests opportunities for refining campaigns. The study emphasizes the need for targeted outreach and community-driven initiatives to enhance SDG understanding among the youth, crucial for effective implementation and a sustainable future.

**Key words:** Sustainable Development goals, Awareness, Personal Interest , Social Interaction and Youth.

## INTRODUCTION

Sustainable development is achievable only by making concerted efforts to meet current needs without compromising the ability of future generations to do the same. Education plays a crucial role in guiding our thinking and behavior towards a sustainable future. The concept of education for sustainable development aims to cultivate a sense of responsibility in the present generation by enhancing awareness of its impact on social, cultural, economic, and environmental spheres in daily life. Given that the Sustainable Development Goals (SDGs) for 2030 prioritize social and economic development, it is imperative to raise awareness among the current youth. A literature review indicates that many young individuals are unaware of the SDGs. According to the United Nations records, there are 1.8 billion individuals aged between 10 and 24 years old. These youth represent a key demographic that must be educated and empowered to become responsible citizens and agents of positive change for our environment. Recognizing that youth are vibrant and critical thinkers capable of propelling the current generation forward, the primary objective of this study is to assess the awareness levels of youth. This is essential as the future of sustainable development lies in the hands of the present youth.





**Jeena Antony and Reeta Babu****Statement of the problem**

The SDGs offer a universal agenda that unites countries, organizations, and individuals worldwide. They create a common language and set of objectives for tackling various issues, such as poverty, inequality, climate change, education, healthcare, and more. So it is important that everyone must be aware about the SDGs goals. The study aims to identify the awareness level of SDG goals among professionals.

**Statement of the problem**

The SDGs offer a universal agenda that unites countries, organizations, and individuals worldwide. They create a common language and set of objectives for tackling various issues, such as poverty, inequality, climate change, education, healthcare, and more. So it is important that everyone must be aware about the SDGs goals. The study aims to identify the awareness level of SDG goals among professionals.

The primary study was done by using the questionnaire. Data was collected from 50 samples. The sampling technique used was convenience sampling. The sample was collected from the youth in Ernakulam District. The data has been analyzed by the SPSS tool.

**Limitations of the study**

The study is based on the views of 50 respondents of Ernakulam district of Kerala.

**REVIEW OF LITERATURE**

Gavilan.A.,Esteban A, Alonso M., Raposeiras A, Quesada D., Rogado G (2024) Engineering students' awareness of sustainable development, particularly with regard to the 2030 Agenda and SDGs, was much enhanced by the introduction of classroom debate sessions. The campaign was deemed successful based on the positive comments received from a satisfaction survey and the media coverage it generated. This led to an increase in the exposure and societal acknowledgment of engineering careers.

**Brondo M., Camilleri N., Melo A., Atares A., Lull C (2022)** Students are aware of the SDGs, according to the report, but the majority believe that the goals are crucial to their everyday lives even though they do not completely comprehend the 17 goals or how they are currently being implemented.

**Yuan X., Yu L., Wu H., (2021)** The findings demonstrate that students' knowledge and information sources about the SDGs are limited, and that there is no difference between gender in terms of knowledge, information sources, learning level, the influence of personal life, or career planning.

**Ghazi H., Abdalqader M., Baobaid M., (2020)** The majority of respondents (35.5%) mostly sourced their information from the internet, with only 77.8% having heard of the Sustainable Development Goals (SDG). Thirty-two percent of them were aware that the SDGs needed to be accomplished by 2030. Of those surveyed, just 50% were aware that there are actually 17 SDGs, and only 45.3% were aware that there are 169 targets in total.

**Gonzalez E., Fontana R., Azcarate P (2020)** analysis was conducted on three dimensions: methodological techniques, Education for Sustainability, and the Sustainable Development Goals. Overall growth was seen in all areas, with notable breakthroughs in comprehension of the Sustainable Development Goals standing out. The methodological solutions that were suggested at the end of the training process stayed the same, even though student instructors showed a growing perception of Education for Sustainability towards more complicated views.





**Jeena Antony and Reeta Babu**

**Data analysis and interpretation**

Variables	Category	No. of Respondents	Percentage
Age	Below 20 Years	8	16
	20-25 Years	32	64
	25-30 years	10	20
Qualification	Graduate	33	66
	Post Graduate	7	14
	Others	10	20
Gender	Male	9	18
	Female	41	82

From the above table it is clear that 64% of the respondents belong to the age category of 20-25 years. 66% of the respondents are graduates. Majority (82%) of the respondents are female.

**Testing of Hypothesis**

Ho: There is a significant difference between personal interest and awareness level.

**ANOVA**

Awareness level

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.380	3	.460	6.2436	.000
Within Groups	.000	46	.000		
Total	1.380	49			

From the above table it is clear that there exists a significant relationship between personal interest and awareness level because the p value is less than 0.05.

Ho: There is no significant difference between gender and awareness level

**One-Sample Statistics**

	N	Mean	Std. Deviation	Std. Error Mean
gender of respondents	50	1.7800	.41845	.05918
Awareness level	50	3.1400	.16782	.02373





### Jeena Antony and Reeta Babu

#### One-Sample Test

	Test Value = 0					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
gender of respondents	30.079	49	.000	1.78000	1.6611	1.8989
Awareness level	132.304	49	.000	3.14000	3.0923	3.1877

From the above table it is clear that there exist a significant relationship between gender and awareness level because the p value is less than 0.05.

#### FINDINGS

- Majority of the youth belong to the age category 25-30 years.
- Almost all of the respondents possess a degree as a basic qualification.
- Majority of the respondents are female
- Around 71% of the respondents have good knowledge about SDGs.
- Majority of the respondents agree with the statement that they have personal interest in understanding the SDGs.
- Majority of the respondents disagree with the statement that they don't actively seek out information related to SDGs.
- Majority of the respondents agree with the statement that they are frequently engaged in discussions with social networks about SDGs.
- Majority of the respondents are neutral towards the awareness level of SDGs.
- There is a significant difference between gender and awareness level of the respondents.
- There is a significant difference between the personal interest and awareness level of the respondents.

#### SUGGESTIONS

The active engagement and social networks identified in the research to enhance community-driven awareness campaigns, fostering a deeper understanding of SDGs among the youth. The targeted outreach programs and innovative communication strategies to bridge the knowledge gap and ensure a more comprehensive understanding of sustainable development goals.

#### CONCLUSION

The study concluded that the research on youth awareness of SDGs reveals a positive trend of engagement, with a focus on the younger demographic and well-educated individuals. The findings underscore successful efforts in fostering knowledge and personal interest in SDGs among the surveyed youth. While the active information-seeking behavior and social engagement are commendable, the presence of a neutral stance on awareness suggests an opportunity to refine and tailor their awareness campaigns for a more impactful reach.

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## Sustainable Marketing for Micro Enterprises: A Study of Challenges and Achieving Growth Focusing on Koratty Grama Panchayat

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### ABSTRACT

This study critically examines the obstacles faced by micro enterprises within the realm of sustainable marketing, shedding light on the integral role of micro enterprises in achieving overall economic sustainability. Recognizing that true sustainability includes the growth of not only large corporations but also micro and rural sectors. Among these challenges, important issues such as a lack of financial resources and unavailability of essential marketing tools are studied. In response to these challenges, the study suggests practical and effective sustainable marketing strategies that micro enterprises can successfully adopt. The study advocates for the increased adoption of digital marketing, giving importance for leveraging social media platforms. In the current social scenario, digital marketing, especially through social media channels, emerges as a comprehensive and accessible strategy for micro firms to enhance their visibility and reach a wider audience. This study helps us understand the problems micro businesses face and gives practical suggestions. It suggests we should use marketing plans that include everyone and can change as needed. This way, micro businesses can do well in the changing world of sustainable business.

**Keywords:** Sustainable Marketing, Marketing strategies, Micro enterprises, Digital marketing, Social media marketing.



**Gouri and Reeta Babu**

## INTRODUCTION

Micro enterprises play a major role in economy of India by contributing around more than 29% of total GDP of the country. A micro enterprise is one with an investment less than 1 crore for both manufacturing and service Enterprises and a turnover not more than 5 crores. They are small-scale businesses with a limited number of employees, typically fewer than 10. These businesses play a crucial role in local economies, especially in rural and underserved areas. Micro enterprises often operate in diverse sectors such as agriculture, retail, and services. Due to their size, they face unique challenges, including limited resources, access to finance, and market reach. However, they contribute significantly to employment generation and community development. Supporting the growth and sustainability of micro enterprises is vital for fostering economic resilience and inclusive development at the grassroots level. Micro enterprises are important for the growth of the Indian economy as they are the primary driver for economic growth in the country. They provide employment to number of people and help in the development of the local economy. They also help to reduce poverty levels and contribute to the overall development of the country.

### Statement of Problem

Examine the obstacles encountered by micro enterprises in the implementation of sustainable marketing and propose practical and effective strategies that these businesses can adopt for sustainable marketing practices. The main problem addressed in this study is to identify and understand the challenges encountered by micro enterprises in implementing sustainable marketing practices. This research aims to explore the barriers that hinder the effective adoption of sustainable marketing among micro enterprises. Additionally, the study seeks to provide actionable strategies to overcome these challenges, facilitating the integration of sustainable marketing approaches into the business practices of micro enterprises

### Objectives of Study

- i. To examine the challenges experienced by micro enterprises in the context of sustainable marketing.
- ii. To suggest practical and effective strategies for the sustainable marketing of micro enterprises.

### Significance of Study

This research holds significant importance for micro enterprises in rural areas by providing them with insights and strategies for sustainable marketing practices. By understanding the challenges faced by these businesses, it gives micro enterprises ideas on how to promote their products or services in a way that is good for the environment and helps them grow. By understanding the problems these businesses face, the study gives them advice on how to connect with the people who might want to buy from them. This is important for their success in the changing world of business. By using sustainable marketing, these small businesses not only help themselves but also make the local economy stronger. It's like a guide for them to be more successful and do good things for their community.

## RESEARCH METHODOLOGY

The study employs both quantitative and qualitative research methods, utilizing both primary and secondary data. Primary data is gathered from 50 micro-enterprises across various locations in Koratty Grama Panchayat through questionnaires and personal interviews. Secondary data is sourced from websites, newspapers, journals, and articles. The study employs convenience sampling for participant selection and utilizes percentage analysis for data interpretation.

### Limitations

The study is based on 50 micro enterprises of koratty Grama panchayat, Thrissur, Kerala. The analysis and conclusion are based knowledge and experience of those who participated in the survey





**Gouri and Reeta Babu**

## LITERATURE REVIEW

Hidayat, M., Salam, R., Hidayat, Y. S., Sutira, A., & Nugrahanti, T. P. (2022): Companies prioritize sustainable development using digital models for customer satisfaction and profitability. Online engagement relies on user-generated content, while new digital business models provide insights into user behaviour. Organizations now rely heavily on digital marketing to disseminate and communicate their ongoing actions and to get insight into how users behave and interact with them on the Internet.

Mandal, P. C. (2022): Companies must care about society and the environment, not just profits. Businesses need to realize their impact on the environment and take responsibility. The study shows why sustainable marketing is crucial, teaching everyone their role in making society better

Trivedi, K., Trivedi, P., & Goswami, V. (2018): Adopting sustainable practices boosts business value by ensuring customer loyalty, attracting investors, and staying ahead. In challenging times, emphasizing sustainable social development is crucial. Marketers contribute by transparently communicating a commitment to sustainability, fostering trust and innovation.

Rathore, B. (2017): The businesses can make money while also taking care of the environment. It explores different ways, like green branding and cause-related marketing. Involving customers, employees, and others is crucial.

Chaturvedi, V., & Yadav, D. S. (2012): Rural marketing plays a crucial role in driving growth. Both major brands and emerging players are actively pursuing the untapped potential of rural markets, aiming to enhance revenues and overall growth. The present paper develops an insight for different concerned to explore rural marketing potential to contribute in development of economy at large.

### Data analysis and interpretation

#### Interpretation

From the collected sample 76% of micro firms in rural market face problems on finding budget for sustainable marketing activities. They find it difficult to choose marketing activities which are more expensive in nature.

#### Interpretation

According to the sample, majority of firms lack knowledge about Networking activities and they cannot afford to have expensive networking for their business.

#### Interpretation

From the data 52% of firms find digital marketing as a relevant option for them when suggested. They find it easier and adaptable way of marketing for them.

#### Interpretation

Many companies heavily rely on customer feedback as a critical aspect of their operations. The feedback provided by customers holds significant importance for these firms, influencing their decisions in selecting and refining their product offerings.

#### Interpretation

The majority of firms consider referral programs, commonly known as word of mouth, to be crucial marketing activities. They highly value word of mouth as it plays an extremely important role for them.

#### Interpretation

Majority of firms are interested in sustainable branding if they can find affordable resources. They believe sustainable branding can improve their value. They believe that adopting sustainable branding practices can enhance their overall value and reputation in the market.





## FINDINGS

1. Most micro enterprises struggle to allocate funds for costly marketing strategies, investing minimally in marketing efforts.
2. Micro enterprises often lack the knowledge and resources required for extensive networking, including the creation and maintenance of a website.
3. The majority of enterprises rely on word of mouth and referrals as their primary means of publicity. Word of mouth is how they spread information about their business.
4. For the majority of firms, customer feedback is crucial, and they highly value it. They determine their product mix by actively seeking and considering customer feedback.
5. The majority of enterprises discovered that digital marketing, especially social media marketing, can be adopted for their marketing needs. It is considered less expensive and very user-friendly, appealing to a wide range of people across all age groups.
6. Based on the findings, it is evident that social media marketing is the most suitable strategy for firms. It is cost-effective, widely used across all age groups, and facilitates easy collection of customer feedback.
7. Micro enterprises have the opportunity to collaborate with local manufacturers for their products, making it easier to source items and expand their publicity collectively.

## CONCLUSION

The concept of sustainability emphasizes inclusivity, requiring the comprehensive growth of all economic sectors. In rural markets, micro enterprises play a significant role in contributing to economic development and creating employment opportunities. The development of micro enterprises is crucial for achieving sustainable economic growth in a country. Due to the unique characteristics of micro-enterprises, they face distinct and specific challenges. The study reveals that most micro industries struggle with budgeting for marketing and lack networking opportunities, such as having a website, which may not be effective in rural areas. The recommended strategy for optimal results is digital marketing, with a focus on social media. Social media is an accessible and cost-effective platform for people of all ages. Utilizing social media marketing tactically can have a significant positive impact on micro enterprises in rural areas. Implementing digital marketing can address both the challenges of a limited budget and a lack of networking resources for micro-enterprises. It is a cost-effective form of marketing that enables easy access to target customers, facilitating efficient communication of feedback between customers and the firm. Another suggested strategy is collaboration with local manufacturers of sustainable materials, providing easier access and mutual business growth. Collaborating with local manufacturers allows micro-enterprises to access goods without incurring substantial supply chain costs. Such collaboration benefits both the manufacturer and the vendor, fostering mutual marketing interests and creating a symbiotic relationship.

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**Table 1: Difficulty in budgeting for sustainable marketing**

Opinions	No of Respondents	Percentage
1. Very low	0	0%
2. Low	6	12%
3. Neutral	2	4%
4. High	38	76%
5. Very High	4	8%
Total	50	100%

*Primary data, questionnaire*

**Table 2: Lack of networking opportunities**

Opinions	No of Respondents	Percentage
1. Very low	0	0%
2. Low	10	20%
3. Neutral	6	12%
4. High	28	56%
5. Very High	6	12%
Total	50	100%

*Primary data, questionnaire*

**Table 3: Relevance of Digital Marketing**

Opinions	No of Respondents	Percentage
1. Not well at all	2	4%
2. Not very well	8	16%
3. Average	6	12%
4. Quite well	26	52%
5. Extremely well	8	16%
Total	50	100%

*Primary data, questionnaire*





**Gouri and Reeta Babu**

**Table 4: Importance of customer feedback**

Opinions	No of Respondents	Percentage
1. strongly disagree	0	0%
2. Disagree	0	0%
3. Neutral	2	4%
4. Agree	32	64%
5. Strongly agree	16	32%
Total	50	100%

Primary data, questionnaire

**Table 5: Importance of referral program (word of mouth)**

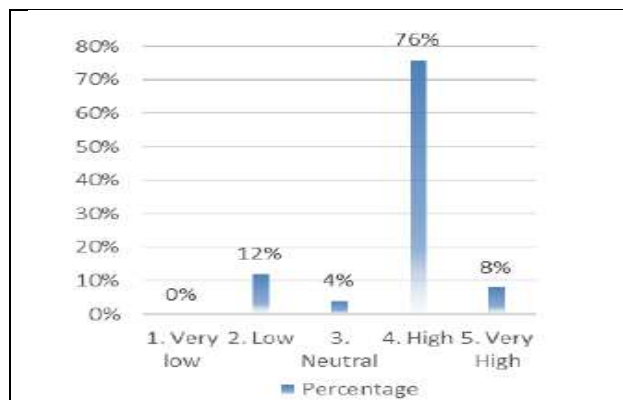
Opinions	No of Respondents	Percentage
1. Not impactful at all	2	4%
2. Slightly impactful	0	0%
3. Moderately impactful	4	8%
4. Very impactful	26	52%
5. Extremely impactful	18	36%
Total	50	100%

Primary data, questionnaire

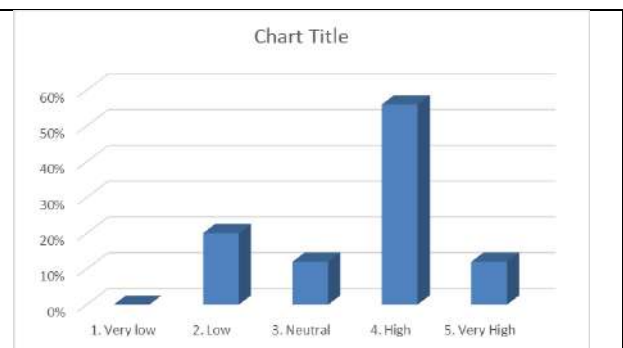
**Table 6: Collaborative sustainable Branding**

Opinion	No of Respondents	Percentage
1. Not Well at All	0	0%
2. Not Well	8	16%
3. Neutral	10	20%
4. Well	22	44%
5. Very Well	10	20%
Total	50	100%

Primary data, questionnaire



**Chart 1 Difficulty in budgeting for sustainable marketing**

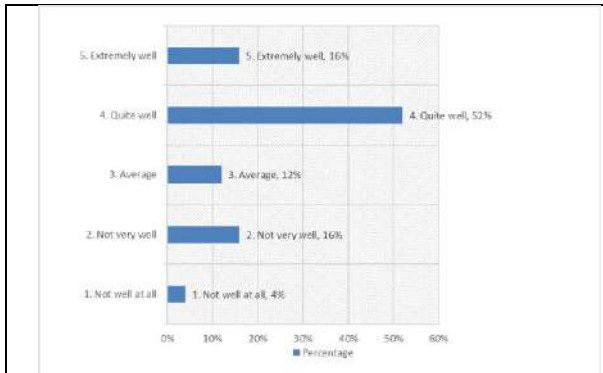


**Chart 2 Lack of networking opportunities**

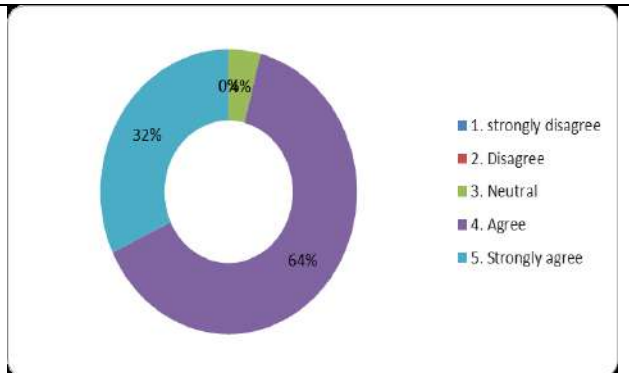




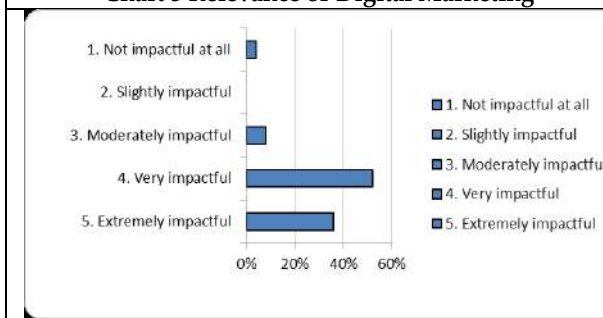
**Gouri and Reeta Babu**



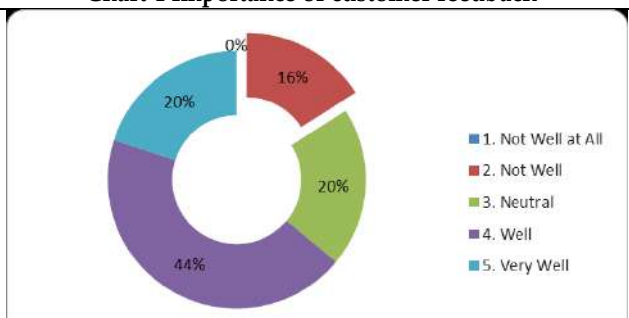
**Chart 3 Relevance of Digital Marketing**



**Chart 4 Importance of customer feedback**



**Chart 5 Importance of referral program (word of mouth)**



**Chart 6 Collaborative sustainable Branding**





## Home Automation using Mitsubishi GOC35 PLC

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### ABSTRACT

A smart home or smart house is a home that has been automated, often known as home automation or demotic. Lighting, climate, entertainment systems, and appliances are just a few examples of the house features that a home automation system may monitor and/or regulate. ABI Research estimates that 1.5 million home automation systems were deployed in the US by 2012. By the end of 2018, more than 45 million smart home gadgets will be deployed in American households, predicts research firm Statista. Systems have traditionally been provided as complete systems, which depend on a single vendor to supply the hardware, communications protocol, central hub, and user interface. Open hardware and open-source software are now alternatives to or complements of proprietary hardware, respectively. These systems frequently connect to common consumer devices like the Arduino or Raspberry Pi, which are available online and in the majority of electronics retailers. Additionally, Bluetooth is being used more frequently by home automation devices to connect with mobile phones, giving users more affordable and customizable options. Home automation systems are very popular right now, both in homes and in businesses. For example, middle class families find it difficult to install this kind of system because of the expensive cost of it. Therefore, our project offers solutions to this kind of issue. We are employing the affordable and dependable Mitsubishi GOC35 PLC in our project. We developed a web application that we use to regulate home appliances.

**Keywords:** Mitsubishi GOC35, PLC, Automation, Software Algorithm, Ethernet.





Kaushika D. Patel *et al.*,

## INTRODUCTION

A microcontroller-based device called a programmable logic controller (PLC) allows us to create smart home automation systems. We can utilize timer programs to fill a water tank, turn on the air conditioner for a set period of time before it automatically turns off, turn on the water heater, and do other operations like turning on and off our homes' lights or having doors open and close on their own. Mitsubishi GOC35, on the other hand, includes PLC features including flexible hardware configuration, configurable special functionality to digital inputs in the main unit, support for interrupt events, common programming platform (CoDeSys), and a user-friendly GUI hardware tool. Despite the great number of home automation systems, very few of them are installed in homes. The primary goal of our project is to create and offer the smallest families a system that is affordable and reliable. Using a ladder diagram-programmed GOC35 PLC device, we are managing household appliances. and create a user interface in the C#(.NET) programming language.

## LITERATURE REVIEW

### PLC INTRODUCTION

PLC stands for Program-controlled logic device. Digital computer without a display, mouse, or keyboard. Emphasizes automating numerous electro-mechanical processes used in a variety of businesses designed and put into use controllers that have well-programmed microprocessors and are resistant to extremes in humidity, temperature, dust, etc. Gathers data from input devices or connected sensors, analyses it, and then activates outputs based on pre-programmed settings. Program-controlled logic device is referred to as a PLC. Without a monitor, mouse, or keyboard, a digital computer. Emphasis is placed on automating various electromechanical processes used in many industries. created and implemented controllers with well-programmed microprocessors that can withstand extremes in temperature, humidity, dust, etc. gathers information from connected sensors or input devices, assesses it, and then triggers outputs in accordance with predefined parameters. PLC is an electronic device that provides overall control with incorporated timing, counting, storage and arithmetic functions and control any system with its' input / output units. Basic scheme of the PLC is given in Figure 1. As shown in the figure, PLC is a digital microprocessor system that processes receiving information from sensors or different input units and therefore able to manage output devices. PLC is generally used in automation systems. By using the PLC, the system controlled can be run in long-term with no maintenance. If technical requirements change and increase, the PLC based system can be easily adapted to new conditions with little changes while updating the classical relay-based systems is so expensive and so difficult. PLC needs less space and consumes less energy.

There are different types which can operate under AC or DC supply [2]. PLC is connected to the computer via RS-485 port with PPI (Point to Point Interface) cable. DC type PLCs operate with 24V DC power supply and AC types need 220V AC supply [5-6]. PLC modules include power supply, CPU and memory, input output, and communication interface modules, all of which may be seen on the front and back sides of the Mitsubishi GOC 35 module's PLC. Hence the diagram is shown below with their components of input and output. In this study, a S7-200 CPU224 model PLC, manufactured by Siemens, is used as main controller unit to collect data received from endpoints, to evaluate data collected and to activate the required output units.

This device has 14 digital inputs and 10 channel digital outputs [2]. There is a 10 KB data memory and a 12 KB program memory. It provides 256 timers and 256 Counters [2]. The PLC can also receive data from devices such as encoders with 6 x 30 kHz high-speed counter [2]. Maximum 7 expansion modules such as Analog module, Ethernet module, Profibus module, Position module can be connected to the PLC. In the realized system, output channels of the PLC are increased to 18 by adding digital input / output module.





**Kaushika D. Patel et al.,**

As we know that PLC and the other controller boards are known for their unique features and their own applications, a part of that PLC are highly used in industries with more advantageous than the controller boards, to justify this argument some Comparison between PLC and Controller board which are listed below:

#### Hardware requirements

##### MITSUBISHI NAC GOC 35

The global home automation market is growing, and this helpful technology is becoming increasingly useful for the elderly and disabled, especially those who live alone. With wireless control of lights, fans, air conditioners, televisions, security cameras, electronic doors, computer systems, audio/visual equipment, etc., these systems are available as single port unit devices [13].

GOC is a product that Mitsubishi India owns and uses to introduce low-end automation goods into the Indian market. GOC has its own uses in several fields, including SPM, HVAC, textiles, and packaging. State OF Art - Pune is where the product is made. This model can be divided into two categories:

- Mitsubishi NAC GOC 43
- Mitsubishi NAC GOC 35

Annunciator and PB Lamps, Customizable MIMIC and 48 I/O Capacity, Analog I/O and connectivity of Serial, Ethernet, and MODBUS are built-in features of these models. Micro range graphic-operated controller with PLC+ HMI features , embedded integrated keys. As Mitsubishi GOC 35 have better specifications and key attribute to provide automation system in cheaper cost, the key attributes are listed below:

1. I/O limit: 48
2. 16 I/O and 32 I/O in the main unit
3. Analog, DI/DO, I/O Extension Unit
4. Serial RS232, Serial RS422, and Serial RS485 are available as communication options. Ethernet is also available.
5. Display: Graphical LCD with a resolution of 128 x 64; MODBUS RTU Master/Slave functionality; SD Card section (up to 32GB);
6. power source:400 mA, 9.6-Watt, input voltage 24 VDC (with a ripple of 18 to 30 VDC).
7. Maximum inrush current of 15 Amps for 6 milliseconds.
8. Fusion safety Internally fixed subminiature fuse T630 mA, 250V, Type 372, made by Littelfuse.
9. opposite polarity diode series protection up to 40 V

Mitsubishi NAC GOC 35 have some keys and modules on the main unit as it operates on 24 VDC with 400mA and 9.6watt and the keys are integrated on front end side to operate this module by our use which are shown and describe below:

The below image describes the back-end side of the module which includes the I/O extensions and COM extensions to interface the modules as per requirements.

1. The main unit has a variety of features.
2. Keyboard shortcuts [F1 to F5].
3. HMI buttons for display settings and navigation.
4. 8 lights for the keys.
5. LED run and power indicators that slides in
6. Label that slides in.
7. [+24VDC, 0V, Earth] 24 VDC supply.
8. A block of two 10-pin input terminals.
9. A block with two 10-pin output terminals.
10. IO1 slot.
11. IO2 slot
12. IO slot cover





Kaushika D. Patel *et al.*,

13. COM1 slot
14. COM2 slot pin output terminals.
15. COM slot covers
16. Mounting clamp slots
17. Projected slot size
18. a slot for a microSD Card.

### Software Requirements

There are numerous programming languages for PLCs available on the market. as depicted below:

1. Ladder diagram
2. IL
3. FBD
4. SFC
5. SI
6. CFC

PLC programming is done using ladder diagrams. Essentially, a ladder diagram uses symbols to represent reasoning. Different industries, home automation, advanced automation, etc. all employ ladder diagrams.

The fact that this language is simpler to learn than most others is one of its greatest advantages. Ladder logic uses words such rungs, rails, inputs, outputs, and logic expressions. Rails are vertical lines that go down the leading ends. The rungs of logic are connected to the rails by horizontal lines. Push buttons (NO, NC, etc.) and switches are utilized as inputs. Controllable outputs include motors, pumps, solenoids, and other devices. Input- and output-based control operations are described using logic expressions. CoDeSys software is being used to program the Mitsubishi GOC35 PLC.

### CoDeSys (v2.3)

The CODESYS Group, which has its headquarters in Kempten, is responsible for creating and marketing CODESYS. The business was established in 1994 and was first known as 3S-Smart Software Solutions. In 2018 and 2020, it changed its name to CoDeSys Group / CoDeSys GmbH. In 1994, CODESYS's initial version was released. The CODESYS Development System's licenses are free, and they can be lawfully installed on additional workstations without copy protection

The CODESYS development environment supports the five programming languages for application programming specified in the IEC 61131-3. Programming language IL (instruction list), which resembles assembler. This language has been designated as "deprecated" by IEC 61131-3 user organization PLCopen, which means it cannot be used in future projects.

Programmers can realistically mix relay contacts and coils with LD (ladder diagram), which is akin to programming in Pascal or C. Users can quickly program both Boolean and analogue expressions using the FBD (function block diagram). Programming sequential processes and flows is made easy with the SFC (sequential function chart). In CODESYS, an additional graphical editor is accessible. Software called CoDeSys is created for industrial automation. The platform's fundamental component is the "CODESYS Development System" IEC-61131-3 programming tool. It offers consumers simple, integrated solutions for making use of automation applications easily. Therefore, the fundamental aim is to offer customers useful assistance for their daily needs. CODESYS is a natural Industry 4.0 platform since it has a variety of applications, including Open Source, security features, and an easy link to a cloud-based administration platform. With CODESYS, edge, fog, or cloud controllers can be created. Any IIoT networks can readily exchange data with one another. Listed below is the CoDeSys software interface:

CoDeSys offers a framework that enables us to program PLC and HMI with a single piece of software.



**Kaushika D. Patel et al.,**

As depicted in the block diagram, switches and sensors such as those for temperature, moisture, motion, and wind can be connected as input devices. Now, we can connect actuators like motors, pumps, and home appliances like fans, lights, and air conditioners to see output and control them. The following block diagram represents our project,

Three alternatives are provided for PC and GOC35 PLC communication which are:

Ethernet, serial RS422/485, and RS232

Ethernet wire is being used to link the GOC35 to a nearby PC.

In this manner, a link between the PC and the GOC35 is established. Therefore, we can control home appliances by using a user interface created in the C#(.NET) programming language.

**Flowchart**

Start (open) the user interface from your PC to turn on the home appliances.

Next, to establish a connection between the user interface and the PLC, enter the IP addresses of the GOC35 and GOC PLC PORT in the user interface. Then, using the ping tester button that the user interface provides, confirm the connection between the user interface and the PLC.

If a connection cannot be made, we can manually operate household appliances using GOC35 key K1.

Press the connected button that is available in the user interface if the connection has been made.

Next, turn on the GOC35 Q0 pin-connected ON bulb. Select the Q1 button from the user interface.

By hitting the available button Q1 off on the user interface, we can turn the light OFF.

**Implementation**

When we control household appliances using application software (user interface) and PLC software (CoDeSys), we are referring to home automation utilizing a Mitsubishi GOC35 PLC.

1. To begin, the image is defined as the program of CoDeSys software in which have used ladder diagram for our requirements.

2. Following PLC programming, we created user interfaces (application software) enabling users to control their home appliances. Visual studio software was utilised to create the user interface. The.NET framework was employed in a project that created an application with a windows forms user interface. Create a new form for user interface design using the project option.and designate separate buttons for the GOC IP address, GOC port connection, connect, disconnect, ping test, application exit, and the k1 to k7 key on/off functions. coding it in the C# language.

3. Attach an Ethernet cable to the Mitsubishi GOC35 PLC and the computer. For the purpose of connecting the PLC, configure Ethernet on the PC.as we are using a wired connection

4. The 24 VDC supply terminal block of the GOC35 PLC has three pins: 24 VDC, 0V, and Earth. The negative terminal of the power supply is connected to 0V of GOC35, which is coupled to the 24VDC supply. And positive one is connected to 24 V pin of GOC

5. Household appliances can now be easily connected to the GOC35 PLC. In this project, we are only connecting a lightbulb to the GOC35 for testing purposes, but we may expand it to include other household appliances like bulb, fan, AC any many more.

6. The GOC35 PLC features a 10-pin output terminal block for connecting home appliances. One bulb terminal is connected to Q0, while the other is connected to the neutral of the three-pin connector and the C0 terminal of the GOC35 is linked to the three-pin plug's line.

7. Next, turn on the power and press the connect button on the user interface. Now, when the K1 key is pushed from the user interface, the light will turn on. Similarly, it will turn if we press the turn-off button on the user interface. By pressing the manual keys on the Boards, it will also turn on the bulb in similar way of pressing the same key to off the bulb as manual start the illuminated keys are blinking with the yellow light for the understanding purpose / user's perspective.

**Test case Table**



**Kaushika D. Patel et al.,**

## RESULTS

Mitsubishi GOC35 PLC is connected to the PC through an Ethernet port, as seen in the image below. As we are running our project the output which are gained in the form of bulb which is turns on and the LED s light which are turns on when we are hitting the keys on user interface and for the manual starts the LED is simple blinking. So, the hardware configuration is depicted below, and the graphic below shows how the hardware functions using a user interface (software application). In this project, a GOC35 PLC-based home automation application was developed to provide individuals with a more pleasant and secure living environment. The system has a modular construction and may be simply adapted to living rooms. It is a significant advantage for the system designed because installation on any PC may be accomplished in a few simple steps. In addition, the goal of this project is to create a framework capable of making household appliances more user-friendly and intelligent. The goal of this program is to make home appliances more energy efficient and automated. This monitors the appliances according to a specified schedule, resulting in a smart home system. It can also boost the house's protection and strengthen its security.

Based on the project's goals, the suggested work's findings show that it was carried out successfully and with positive results. By including the sensors to increase the home's security, this work may be made better. To ensure that all the appliances operate more efficiently during scheduling, the user might extend the time that is predetermined.

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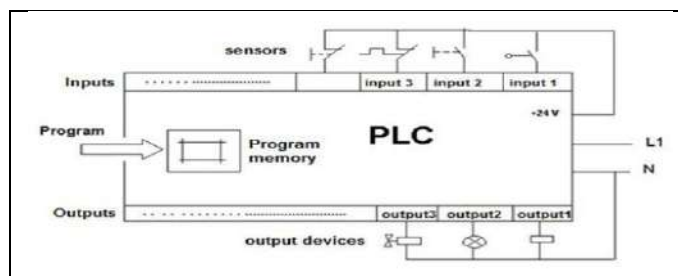
Kaushika D. Patel et al.,

**Table 1. Comparison of PLC and Controller Boards**

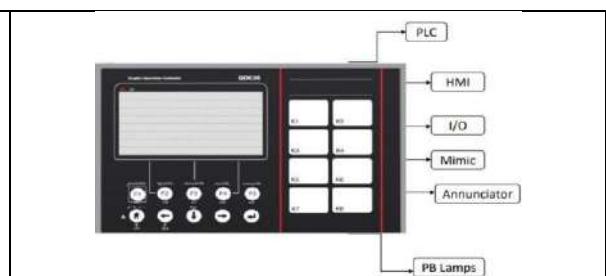
PLC	Controller Boards
Does not need additional external components	Whereas other board, Needed External Components to Work as PLC
Only needed basic operating technique for reprogramming the PLC	Need to learn basic programming to rewrite the other programming.
Reprogramming is easy.	Reprogramming is relatively difficult.
High performance	Satisfactory performance
Can work on harsh conditions	Cannot work in harsh conditions
Many options for choosing	Lesser options for choosing
Little bit high cost	Low cost
Open source / paid software	Open-source software
Customization is possible	Customization is not possible
Real time CPU capabilities	Real time CPU capabilities are not possible

**Table 2. Test Cases**

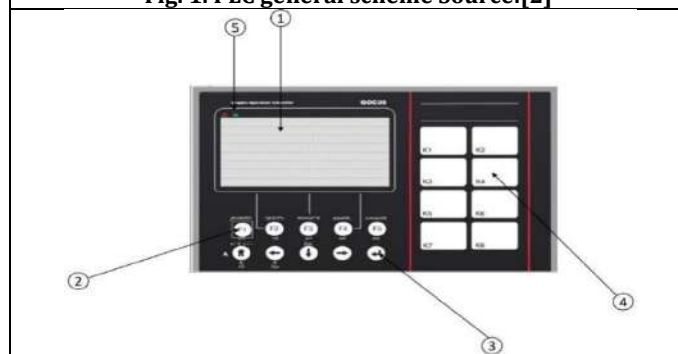
Testcase	Test scenario	Test data	Expected results	Actual results	Status
1	Check bulb is on or off using user interface	Light: ON/OFF	The bulb will light up or OFF.	As expected.	pass
2	Check bulb is on or off using PLC software (CoDeSys)	Light: ON/OFF	The bulb will light up or OFF.	As expected.	pass
3	Check manually from GOC35 PLC	K1: button on/off	The bulb will light up or OFF.	As expected.	pass



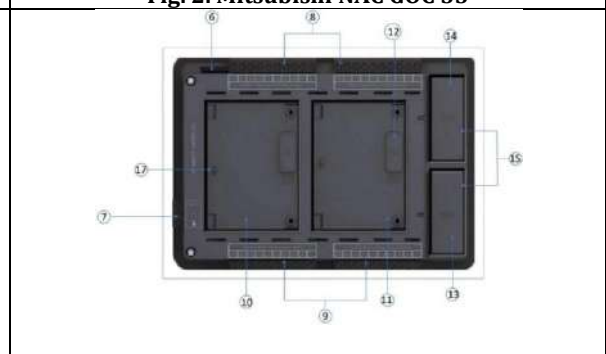
**Fig. 1. PLC general scheme Source:[2]**



**Fig. 2. Mitsubishi NAC GOC 35**



**Fig. 3.1. Main Unit-1**



**Fig. 3.2. Main Unit-2**







Kaushika D. Patel et al.,

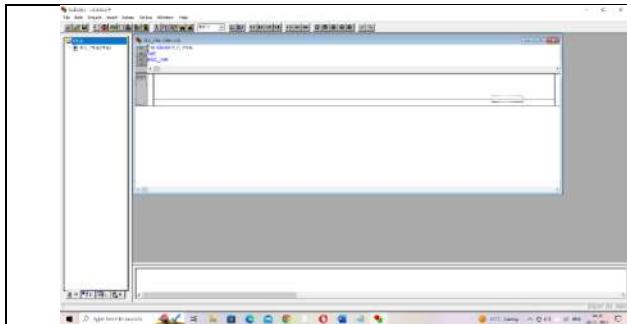


Fig. 4. CoDeSys front view

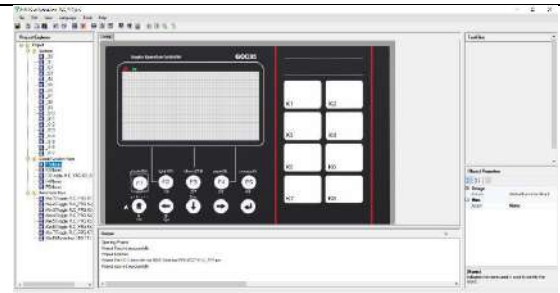


Fig. 5.1. Connection of GOC 35 and Software-Frontend



Fig. 5.2. Connection of GOC 35 and Software- Backend

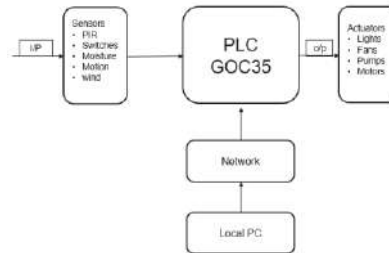


Fig. 6. Block Diagram

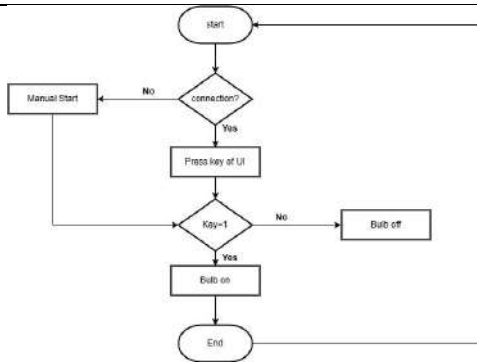


Fig. 7. Flow chart

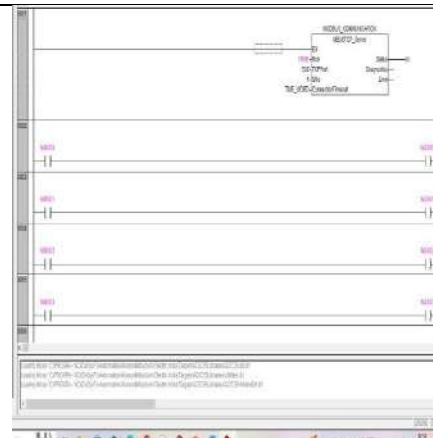


Fig. 8.1. PLC programming-1



Fig. 8.2. PLC programming-2

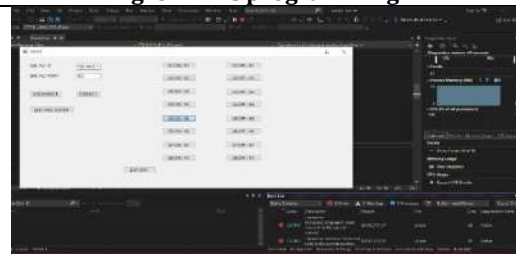


Fig. 9. User Interface

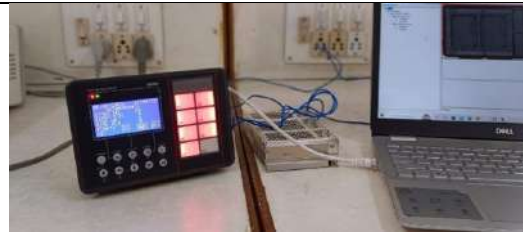




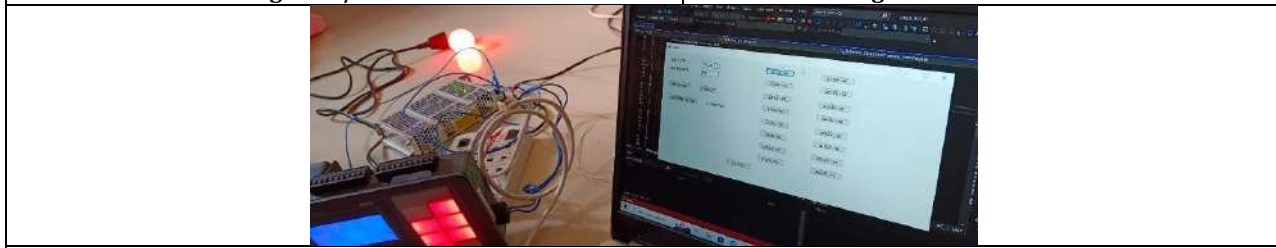
**Kaushika D. Patel et al.,**



**Fig.10. U/I Result**



**Fig.11. Hardware result**



**Fig.12. Result**





## Application of Block Chain in Elections

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### ABSTRACT

Elections. It is the process by which one person gets elected for a very important job. In history, one of the first and most popular elections were held in sparta to decide the government officials. In a democratic country like India, elections are a very important event. It decides who will be responsible for a country's decisions. Here, the first major elections were held on 25 October 1951 and 21 February 1952. So countries should try to make their elections more competitive and fair to elect the right person. [1] In 2004, EVM machines were introduced to improve the elections. With time, old methods must be improved, and new ones should be made. In this paper, we have discussed the chance of a 100% tamper proof elections with the help of block chains. We have discussed the potential of the digital ledger and the working of different bodies in elections using block chain. Different identification methods, smart contracts, work required is also discussed.

**Keywords:** Elections; Block chain; Hashing; Borda Count; Elections Commission

## INTRODUCTION

In various countries there are many problems related to elections through which wrong candidates get elected. This declines the country's development which results in unhappy civilians. The problems are:

1. India, Booth capturing and rigging
2. USA, Rigging via hacking.
3. Russia, Ballot suffering
4. UK, Proxy voting.





**Iftikhar Haider et al.,**

5. Germany, EVM sare proneto hacking
6. Ireland, EVM slack transparency and trust

Block chain is a technology which is used as an advanced database. This database allows transparency and informationsharingwithinanetwork.Manycountrieswhosuccessfullyranelectionsthroughblockchainare:

- Tsukuba, Japan-It was used in a social experiment.
- West Virginia, USA-successful use.
- Sierra Leone-The result was not accepted.
- Russia-Moscow city elections conducted.
- African Nations-Successful use.
- Parliament of Nauru-Successful.
- National Assembly of Slovenia-Successful

Looking at the government's perspective, the voters trust can be attained by making our voting system more secure and accurate. Block chain is very secure because of it's incorruptible ledger system that is very secure and cannot beat tacked[7]This paper is made by in incorporating many techniques and methods to minimize the drawbacks.

## METHODOLOGY

This paper discusses how block chain will be applied in elections. Block chain is nothing but a public distributed database which holds an information called encrypted ledger. One block of a block chain is the collection of transactions that had happened and are verified by the miner. A miner is a person who is responsible for adding the block into the chain, and they also keep and update there cord of the block chain. One block contains the following: Block chain solves many problems with current technologies. For example, in banking, block chain reduces the chances of double spending. Double spending is a term in digital banking where a person uses on payment token (it can be bit coin, ethers etc.)to pay 2 or more times[9]. As each transaction is checked by the miner before adding the transaction to the block chain and processing it, block chain handles the problem of doubles pending. It decentralizes power between many miner sand boot nodes(explained later in the paper). This prevents power being in one person's hand. Block chain has a distributed/public ledger. A ledger is a collection of records of a transaction. When a new user becomes part of the block chain system, he/she gets a whole copy of the block chain. This ledger holds records from the start of the block chain. This doesn't mean that any body who is part of the block chain will have each information of the transaction. The private key of the two parties in a transaction is kept hidden, which promises an onymity. Block chain is less prone to hacks. This system is built so securely that any transaction which is changed will be rejected. Let us consider a digital monetary transferecase to explain the above points. A person X has 400 bit coins in his bit coin wallet. He wants to send 500 bit coins to a person Y. Person X willfirstaskforY'saccountnumber.Hewillinitiatethetransaction.Thistransactionisthensentoaminerwhochecksthe entire history of person X's transactions. The miner will reject this transaction as X has a low balance. If X had600 bit coins in his account, then the miner would have confirmed the transaction, and this would be broadcasted to the whole block chain. Each transaction takes about 10 minutes to verify. These main technologies behind the success of block chain

1. Private Key Cryptography
2. P2Pnetwork
3. Hashing
4. PHANTOM
5. Borda Count

This paper discussed that each and every member of the block chain gets a copy of the block chain and also knows when a transaction is made. This is achieved by P2Pnetwork.Forexample, a person A is connected to person B on the block chain. When A completes a transaction, B gets the broadcast. Then B sends the broadcast to C and then it goes on. Each and every person in a block chain is connected so there is no chance of a person not





**Iftikhar Haider et al.,**

This paper discussed that each and every member of the blockchain gets a copy of the blockchain and also knows when a transaction is made. This is achieved by P2P network. For example, a person A is connected to person B on the segment communication protocol and validates contemporary blocks[5]. Hash is a 64 digit blockchain. When A completes a transaction, B gets the broadcast. Then B sends the broadcast to C and then it goes on. Each and every person in a blockchain is connected so there is no chance of a person not getting the broadcast. So basically, a blockchain is managed to be used as a distributed ledger by a point-to-point network that together adheres towards hexadecimal number which. The hashing can be done by an algorithm which is very complex and very precise.

The hash function can be made by using a mathematical calculation that is very complex. This can be explained by a simple formula:

$H(x)=x\%n$ , where  $x$  and  $n$  are integers and  $\%$  modular operation. Now this operation can be made as complex as possible to make a unique hash every time. This is made cryptographically secure by making this formula one way. We can calculate  $H(x)$  by  $n$  and  $x$  values but we can't calculate  $n$  and  $x$  values by  $H(x)$ . Another reason for hashing being perfect is for different values of  $x$  for example  $x_1$  and  $x_2$ ,  $H(x_1)$  and  $H(x_2)$  will be different. In hashing an avalanche effect is seen where a small change in the data set would result in a significant change in output.

When a miner verifies a transaction, he/she also gives the hash value to the block. This is done with the help of a nonce. Nonce is a 32 bit number used to make the base of the hash calculation. A miner can create many nonce to guess correctly what the nonce value is like the hash value that is supposed to be of that block. As said above, this hash value is created by different algorithms. When A would send money to B, their public key and the amount sent is called data. In a voting program, this data can be the public key of the voter, his/her Aadhaar, their vote etc. This data gets into a hash algorithm which assigns a hash value to the data. With the help of the private key this data gets encrypted.

A person can change the information of the transaction while the transaction is being propagated (in case of double spending). This is prevented by the miner or verifier. If a person changes the information, his/her hash value will be different. This hash value will be compared to the hash value before. The transaction will not go further as the checked hash value would not match. A miner verifies each transaction by solving a complex mathematical problem. Then he/she updates the chain. Another concept to be discussed in this paper is PHANTOM. This is an advanced version of a blockchain which makes the blockchain computationally faster and more accurate.

The above mentioned way of verifying a transaction takes a lot of time (10 min). PHANTOM uses block DAG which helps us identify a honest block (honest vote). DAG stands for directed acyclic graph and it is used to model and structure a blockchain. Here instead of a chain, DAG forms a tree like structure from the blocks (Fig. 2.)

**Borda Count:** This can be used to prevent threatening votes and booth capture. Here we can use rank voting system. Voters will rank the candidates in the order of their liking. What we propose is new, updated EVM machines that will have all the candidates and 4 buttons beside each candidate names which will represent their rank. A voter will choose 1 for a candidate giving him/her 3 points. Then the voter will choose 2 for another candidate giving them 2 points and so on. The points of the candidate will be calculated and the winner will be announced. Now suppose there is an election and there are 4 candidates. Let us suppose that there are 2 threatened voters out of 4: Voter 1, Voter 2. Now voter 1 was forced to vote for candidate C which he/she did, But the benefit of this system is that voter 1 can vote for their favorite candidate as second preference. Voter 2 also did the same. This is the observation:

Total Points (A) = ( number of 1st preference \* 3) + (number of 2nd preference \* 2) + (number of 3rd preference \* 1) + (number of 4th preference \* 0) = 3

Total Points (B) = ( number of 1st preference \* 3) + (number of 2nd preference \* 2) + (number of 3rd preference \* 1) + (number of 4th preference \* 0) = 10





**Iftikhar Haider et al.,**

Total Points (C) = ( number of 1st preference \* 3) + (number of 2nd preference \* 2) + (number of 3rd preference \* 1) + (number of 4th preference \* 0) = 8

Total Points (D) = ( number of 1st preference \* 3) + (number of 2nd preference \* 2) + (number of 3rd preference \* 1) + (number of 4th preference \* 0) = 3

Hence candidate B will be elected.

For elections every voter has to have an identification proof (Aadhaar). This will get them registered for the elections.

[3] There are different pillars in this election:

- Voters
- Government identification verification service
- The election administrator
- Authentication
- Smart Contract
- Bootnode
- Constituency Node
- National Node
- Blockchain

These pillars, along with certain authentication processes can be used to conduct election. First, the voters will be asked to register themselves with the Election Commission of India . Aadhaar card is issued only if we register our biometric with the government. So even biometric can be used to authenticate a voter. But this practice is frowned upon as there can be problems with the scanners. Government identification verification service will make a data of all the voters. Now, the election administrator will issue the smart contract which will go to the Bootnode for connection with the voter. A smart contract is a contract between two parties in which a set of rules is defined in such a way that the program will run only if those rules are abided by. Smart contracts can be created using Ethereum. The Smart Contracts would be cross-confirming the votes got with the quantity of voter's casted a ballot altogether against all applicants [6]. Ethereum can be called a programmable Bitcoin that can be used by developers to make contracts [8]

It is a public, open source blockchain based computing platform. So smart contracts are nothing but a set of rules written digitally and they can't be changed. Bootnodes are just regular nodes that are used to connect to other nodes. It is the one that will get the vote from the voters or nodes and combine them. There are constituency nodes and the national nodes. Constituency nodes will hold the public and the private key. National node is the final node where information from all the other nodes will be stored.

This process is done before the election. On the day of the election the voters will go to their local voting booth which will have new EVM machines. These EVM machines will be set up the same way they were done before (wax, strings). Boot node will play a major role here. They will confirm the vote of the person by matching the credentials with the smart contract.

The Election Commission will begin the elections and national node will inform constituency node to start their process. There will be different constituency nodes for different states or districts. Constituency node will generate a public key which will be used to encrypt the vote of the people. This encrypted vote will be checked by the boot node for any dishonest vote. Honest votes will be put inside the PHANTOM. Each winning candidate's name will be sent to the election administrator. This was the winner be declared. Constituency node will collect all the votes and it will be sent to the National Node (Election Commission) with a private key. This private key will be used to decrypt the votes to calculate the total number of points. Later, the winner will be announced.







Iftikhar Haider et al.,

## DISCUSSION

As this is a survey research paper, we have incorporated techniques from other's experiences to create a system. Overall, application of blockchain will give us better results and faster. These results will be tempering proof. This is a very efficient way, but the idea will still take time to be implemented in India, as this method requires trained personnel to handle the blockchain. The change of our usual election patterns will take time. New booths will be made. The Election commission of India reportedly spent INR 35000 crores in polling for the 2014 Lok Sabha Elections [9]. All this takes a lot of research and planning.

## CONCLUSION

In this paper we have introduced a new and advanced way of conducting elections with the use of blockchain technology that further uses an advanced version of blockchain i.e; PHANTOM. PHANTOM would make the process of voting fast. We have combined PHANTOM with Borda Count method to ensure that there are no threatened votes. An elaborate system was developed to help understand the structure in which the election body would have to work. A group of highly trained professionals would be needed to implement blockchain. For countries of greater size, a broader system would be needed.

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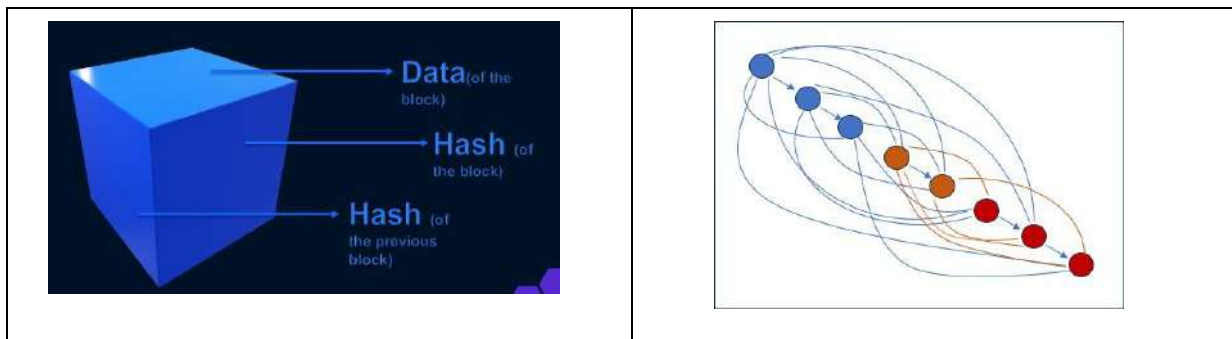




**Iftikhar Haider et al.,**

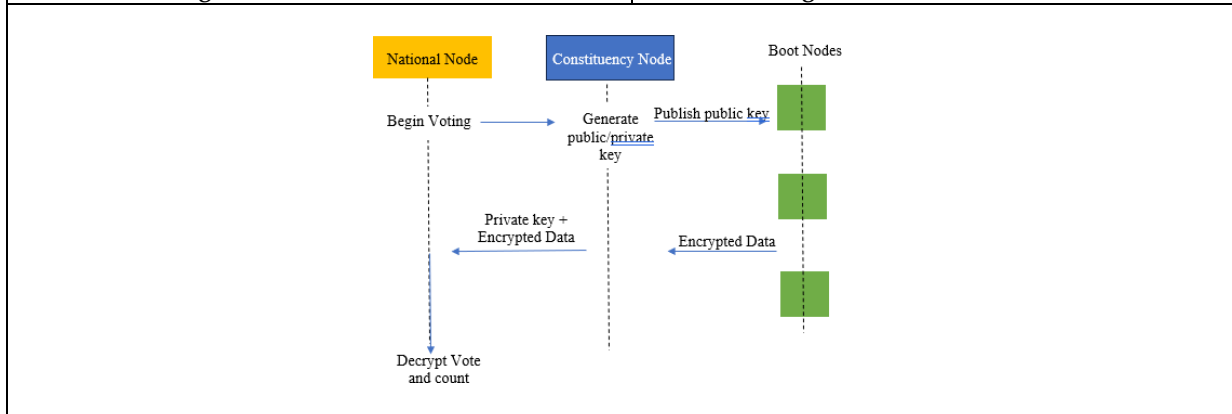
**Table 1. Example for Borda Count**

Borda Count	Voter 1	Voter 2	Voter 3	Voter 4
3	C	C	B	B
2	B	B	C	A
1	A	D	D	D
0	D	A	A	C



**Fig. 1. Structure of a block**

**Fig. 2. Block DAG formation**



**Fig. 3. Working of nodes**





## Health Risk Prediction using Deep Learning Approach

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### ABSTRACT

Human beings, known for their intelligence and inherent health consciousness, have developed and adopted effective healthcare systems over centuries. In recent times, health become major concern. Nowadays, early fatality and disease prevention have become crucial areas of focus in healthcare. The ability to detect and intervene in health conditions at their early stages can significantly impact patient outcomes and improve overall population health. With advancements in technology and the availability of vast amounts of health data, there is a growing interest in leveraging machine learning and artificial intelligence techniques to develop predictive models that can identify individuals at higher risk of fatality and disease. Deep Neural Network approach is applied with multi layer perceptron for the prediction of health risk. Extensive method and filtering technique has been done on a real world dataset stored in cloud and result shows improvement of our proposed algorithm over the state of the art.

**Keywords:** Deep neural Network, Filtering Technique, Health Prediction, Cloud, multilayer perceptron

## INTRODUCTION

Health risk prediction plays a vital role in healthcare by enabling early identification and intervention for individuals at risk of developing various health conditions. Accurate prediction models provide valuable insights into disease progression, guide personalized treatment strategies, and promote preventive measures. In recent years, deep learning approaches have emerged as promising methods for health risk prediction, leveraging the power of artificial neural networks to analyze complex healthcare data and uncover hidden patterns and relationships. Deep learning, a subfield of machine learning, focuses on training artificial neural networks with multiple layers to automatically learn hierarchical representations of data. Deep learning models have achieved remarkable success in various



**Rajesh Babu Ahirwar et al.,**

domains, including computer vision and natural language processing, and now hold great potential for transforming healthcare. The application of deep learning in health risk prediction can revolutionize healthcare delivery. By leveraging diverse datasets such as electronic health records, genomic data, wearable device measurements, and even social media data, deep learning models can extract valuable insights and make accurate predictions regarding individuals' health risks. These predictions assist healthcare providers in early intervention, personalized treatment planning, and targeted preventive strategies. The strengths of deep learning lie in its ability to automatically learn relevant features from raw data without the need for explicit feature engineering. Through multiple layers of interconnected neurons, deep learning models capture complex patterns, interactions, and dependencies within the data, enabling them to uncover hidden risk factors and make precise predictions. However, alongside their potential, the application of deep learning in health risk prediction also presents challenges and considerations. The interpretability and explainability of deep learning models remain areas of concern, given the complex nature of neural networks and the difficulty in understanding their reasoning. Data quality, privacy, and ethical considerations also require attention when utilizing deep learning methods in healthcare.

This research paper aims to provide a comprehensive review of deep learning approaches in health risk prediction. We will discuss various deep learning architectures and techniques, explore different data sources used in health risk prediction, examine the performance and limitations of deep learning models, and address future directions and challenges in this rapidly evolving field. By illuminating the potential of deep learning in health risk prediction, this research paper contributes to the advancement of personalized healthcare and preventive strategies. The insights gained from this study will guide researchers, healthcare professionals, and policymakers in harnessing the power of deep learning for more accurate and timely health risk prediction, ultimately improving patient outcomes and public health. Park et al. (2020) proposed a deep learning model for predicting cardiovascular diseases using electronic health records (EHR) data. They employed a combination of convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to capture both spatial and temporal patterns in the data. Their model achieved an accuracy of 86% in identifying individuals at high risk of cardiovascular diseases. Li et al. (2019) In their research, Li et al. (2019) investigated the use of deep learning for cancer risk prediction based on genomic data. They developed a deep neural network that integrated genetic variants and clinical features. Their model achieved an area under the curve (AUC) of 0.92, outperforming traditional machine learning methods in predicting cancer risk. Kim et al. (2018)

Kim et al. (2018) focused on predicting the onset of diabetes using deep learning models. They employed a recurrent neural network architecture with attention mechanisms to analyze longitudinal electronic health records. Their model achieved an F1-score of 0.81 in identifying individuals at risk of diabetes, showcasing the potential of deep learning in early disease detection. Chen et al. (2017) Chen et al. conducted a study on the application of deep learning in medical imaging analysis. They developed a deep convolutional neural network (CNN) model for diagnosing lung cancer from CT scan images. Their model achieved an accuracy of 93% in distinguishing between malignant and benign nodules, showcasing the effectiveness of deep learning in radiology. Mamoshina et al. (2014) Mamoshina et al. conducted a literature review on the applications of deep learning in biomedicine. They explored the use of deep learning models in various areas, including drug discovery, disease diagnosis, and personalized medicine. The review highlighted the potential of deep learning algorithms in analyzing complex biomedical data and contributing to advancements in healthcare. Choi et al. (2013) Choi et al. performed a systematic literature review on deep learning techniques in medical image analysis. They analyzed studies focused on applications such as image segmentation, classification, and registration. The review discussed the effectiveness of deep learning algorithms in improving the accuracy and efficiency of medical image analysis tasks. Ravi et al. (2012) Ravi et al. conducted a literature review on the use of deep learning in healthcare data mining. They explored the application of deep learning models in analyzing various healthcare datasets, including clinical data, genomics data, and medical imaging data. The review discussed the challenges and opportunities of utilizing deep learning techniques for extracting valuable insights from large-scale healthcare datasets Methodology. In this section we present the detailed methodology of our proposed Collaborative Filtering-enhanced Deep Learning (RNN) approach





Rajesh Babu Ahirwar et al.,

### Problem Formulation

1. Define the objective as predicting health risks based on patient data.
2. Let  $X = \{(x_1, y_1), (x_2, y_2), \dots, (x_N, y_N)\}$  be the dataset, where  $N$  is the number of patients.
3.  $x_i$  represents the input features for patient  $i$ , and  $y_i$  represents the corresponding health risk label.

### Data Preprocessing

1. Perform data cleaning, including handling missing values, outliers, and inconsistencies.
2. Normalize the input features to ensure they have similar scales.
3. Split the dataset into training, validation, and testing sets.

### RNN Model Architecture

1. Design the RNN architecture with long short-term memory (LSTM) units to capture temporal dependencies in the sequential patient data.
2. Define the number of LSTM layers, the number of hidden units in each layer, and the activation functions.
3. Specify the input shape and sequence length for the RNN model.
4. Consider techniques like dropout or recurrent dropout to prevent over fitting.

### Training the Model

1. Initialize the model's parameters and hyper parameters.
2. Utilize an optimization algorithm, such as stochastic gradient descent (SGD), Adam, or RMS prop, to train the model.
3. Define an appropriate loss function, such as binary cross-entropy or categorical cross-entropy, to measure the model's performance.
4. Iterate through multiple epochs, adjusting the model's parameters to minimize the loss and improve predictions.
5. Monitor the training process and utilize early stopping if necessary to prevent over fitting.

### Model Evaluation

1. Evaluate the trained RNN model on the validation set to assess its performance and tune hyper parameters if needed.
2. Calculate various performance metrics, including accuracy, precision, recall, F1-score to measure the model's effectiveness in predicting health risks.
3. Analyze and interpret the model's predictions to gain insights into important risk factors and their impact.

## TRAINING AND TESTING

We train a recurrent neural network (RNN) with Three layers, including one input layer, one output layer, and One hidden layers. The output layer utilizes the soft max activation function for multi-class classification. Each layer consists of a variable number of recurrent units. After pre-processing, the input features are represented as a sequence of vectors with a dimension of 139. The number of recurrent units in the input layer matches the input feature dimension, and the number of units in the output layer matches the number of output classes. The RNN processes the sequential input data, capturing temporal dependencies and modeling sequential patterns. The hidden layers allow the network to learn complex representations and extract relevant features from the sequential data.





Rajesh Babu Ahirwar et al.,

## CONCLUSION

This research paper presents a deep learning approach for health risk prediction and provides a comprehensive evaluation of its performance. The results demonstrate the superiority of the proposed model over traditional machine learning algorithms. The findings highlight the potential of deep learning in revolutionizing health risk prediction and guiding personalized healthcare interventions. Further research can focus on optimizing the model architecture, exploring transfer learning techniques, and integrating additional data sources to enhance the accuracy and generalization ability of the predictive model.

## Future Work

Future research in health risk prediction using deep learning approaches should focus on transfer learning techniques, enabling the adaptation and fine-tuning of pre-trained models for specific risk prediction tasks. Additionally, efforts should be directed towards enhancing the explainability and interpretability of deep learning models to gain trust and acceptance in the healthcare community. Integration of genetic data, exploration of longitudinal analysis, development of real-time risk monitoring systems, external validation studies, and addressing privacy and ethical considerations are also crucial areas for future work. By pursuing these avenues, we can advance the field and unlock the potential of deep learning for accurate and actionable health risk prediction.

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age	sex	chest_pain_type	resting_blood_pressure	cholesterol	fasting_blood_sugar	rest_ecg	max_heart_rate	exercise_induced_angina	oldpeak	slope	vessels_colored_by_fluoroscopy	thalassemia	
0	52	Male	Typical angina	125	212	Lower than 120 mg/ml	ST-T wave abnormality	168	No	1.0	Downsloping	Two	Reversible Defect
1	53	Male	Typical angina	140	203	Greater than 120 mg/ml	Normal	155	Yes	3.1	Upsloping	Zero	Reversible Defect
2	70	Male	Typical angina	145	174	Lower than 120 mg/ml	ST-T wave abnormality	125	Yes	2.6	Upsloping	Zero	Reversible Defect
3	61	Male	Typical angina	148	203	Lower than 120 mg/ml	ST-T wave abnormality	161	No	0.0	Downsloping	One	Reversible Defect
4	62	Female	Typical angina	138	294	Greater than 120 mg/ml	ST-T wave abnormality	106	No	1.9	Flat	Three	Fixed Defect

**Fig.1 Sample Dataset**





Rajesh Babu Ahirwar et al.,

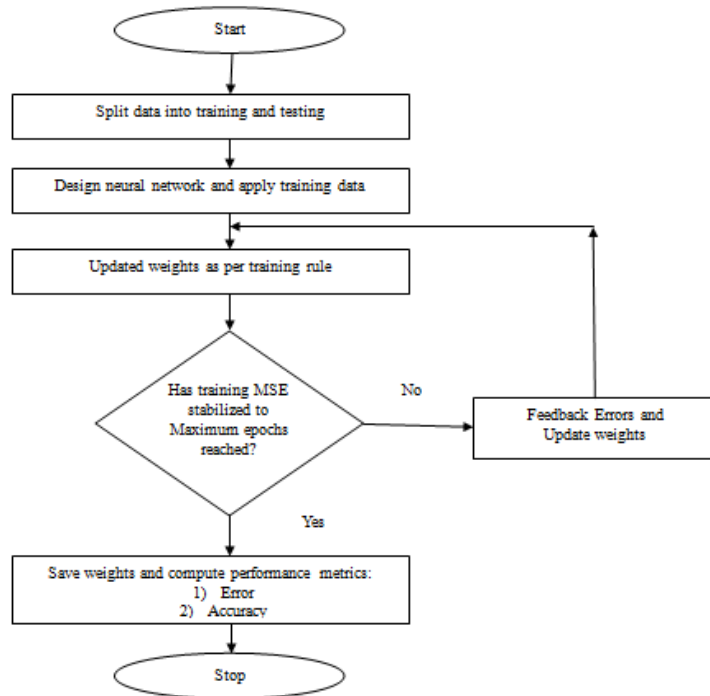


Fig. 2 flowchart of the system

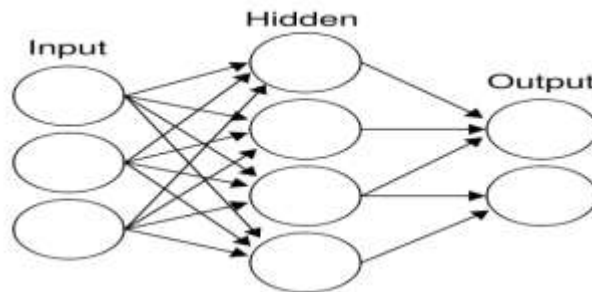
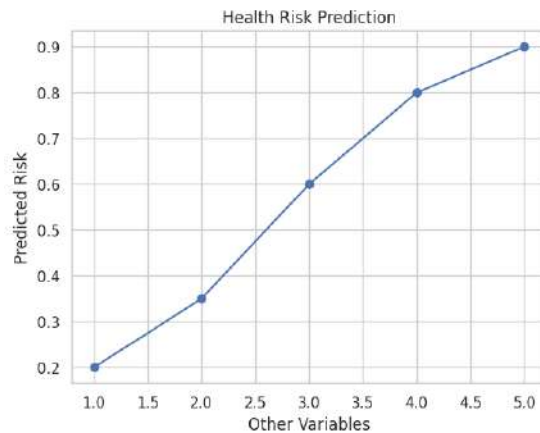


Fig. 3 General Structure of RNN ( Guseo, 2017)

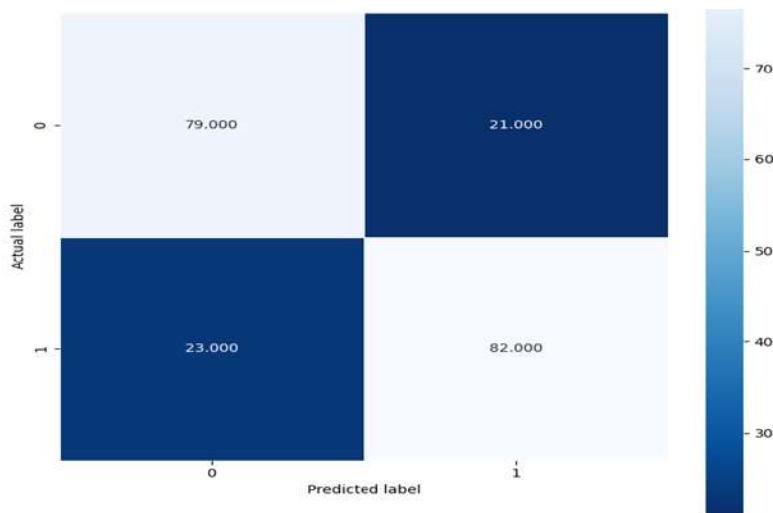




**Rajesh Babu Ahirwar et al.,**



**Fig. 4 Performance on the health risk prediction different variables**



**Fig. 5 Confusion Matrix of the Health Risk Prediction**





## Effect of Phosphate Solubilizing Bacteria on the Growth of *Solanum lycopersicum* L.

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### ABSTRACT

Phosphorus is one of the vital micronutrients for plant growth, most of which remains insoluble in the soil. In this study, phosphate-solubilizing bacteria were obtained from the roots of the tomato (*Solanum lycopersicum*) plant, and Pikovskaya's medium was used for isolation based upon the dissolved phosphorus halo. The isolate that produced halo zones was analyzed further by gram staining and, then the broth medium inoculated with different concentrations (total 11 concentration) bacteria was prepared. Twenty-four plants of tomato (*Solanum lycopersicum* var. pusa ruby) that were planted in pots were then treated with the prepared broth and, for each treatment; two plants were taken to evaluate their beneficial effects on the early growth of tomato plants. Out of all the treatments, treatment no. 11 showed the best results and had the highest concentration of PSB. The highest plant height recorded was 91.5cm, the highest no of fruits recorded was 26.5, and the highest weight recorded was 1193.50g. Upon the analysis of molecular characterization, based on 16S rRNA gene sequence comparisons and phylogenetic positions it was closest (on the adjacent branch in the phylo genetic tree) to the *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence. The Genomic Islands study of antimicrobial resistance genes was also performed in different strains of *Bacillus* including, three pathogenic (*Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5 DNA, and *Bacillus thuringiensis* Bt407) and one non-pathogenic (*Bacillus subtilis* strain NCIB 3610) species. The results of the study showed absence of Genomic Island for Antibiotic resistant gene in *Bacillus anthracis* genome while other three organisms showed presence of GIs. This study concluded that PSB can be used as a potential biofertilizer to increase the growth and yield of the tomato plant.

**Keywords:** Phosphate solubilizing bacteria, rhizospheric soil, tomato plant growth, root-shoot ratio





Shipra Kumari

## INTRODUCTION

In a terrestrial ecosystem, soil microorganisms play a significant role in the recirculation of nutrients in the rhizosphere of plants, which is essential for the long-term viability of the soil. Phosphorus is an essential macronutrient that is necessary for plant growth and development. It affects root growth, stalk and stem strength, crop maturity, and nitrogen fixation in legumes on a macro level. It is a component of biological molecules like DNA, RNA, ATP, and phospholipids. Phosphorus (P) is the second most important macronutrient for plant development in soil after nitrogen, and a lack of P restricts plant growth (Zhang *et al* 2017). P is one of the less prevalent elements in the lithosphere (0.1% of total) when compared to other key macronutrients (apart from N). Chemical fertilizers were a key component of the Green Revolution, but their over usage has reduced soil fertility and degraded the environment. Because the free phosphorus content (the form available to plants) is often less than 10  $\mu\text{M}$  even at pH 6.5 where it is most soluble, many soils around the world are P-deficient (Gyaneshwari *et al.*, 2002). However, due to its essential function in energy transfer (such as ATP), cell structure (phospholipids), metabolism, and signalling, adequate P nutrition is required for all microorganisms (Jones and Oburger, 2011). It is generally recognized that many bacterial species, especially those found in the plant rhizosphere, have the ability to positively influence plant growth. Because of this, many researchers have been concentrating on their usage as biofertilizers or control agents for agriculture improvement for a number of years. The term "plant growth promoting rhizobacteria" (PGPR) has been used to describe this group of bacteria. Strains from genera like *Pseudomonas*, *Azospirillum*, *Burkholderia*, *Bacillus*, *Enterobacter*, *Rhizobium*, *Erwinia*, *Serratia*, *Alcaligenes*, *Arthrobacter*, *Acinetobacter*, and *Flavobacterium* are included in this group (Rodríguez and Fraga, 1999). In canola, lettuce, and tomato, strains of *Pseudomonas putida* and *Pseudomonas fluorescens* have boosted root and shoot elongation (Hallet *et al.*, 1996).

Wheat yield improved by up to 30% with *Azotobacter* inoculation, up to 43% with *Bacillus* inoculants (Klopper *et al.*, 1989) and by up to 10% in field trials when *Bacillus megaterium* and *Azotobacter chroococcum* were combined. In several nations, bacterial inoculants have been employed to boost plant yields, and there are already commercial solutions on the market. These bacteria are able to thrive in media with calcium phosphate complexes as their only source of phosphorus, solubilize and assimilate a significant portion of the phosphorus, and release a significant amount of phosphorus. By synthesizing organic acids, phosphorus is solubilized and released by micro organisms. This reaction, leaves a halo or clear zone on the plate, is used to measure how well these bacteria are able to dissolve P. Undoubtedly, the selections of highly efficient PSB strains as prospective inoculants will be a promising strategy to release huge amount of P from soil to ameliorate the current state of extensive chemical fertilizer usage. The use of phosphate-solubilizing bacteria (PSB) is useful for sustainable agriculture practices due to the harmful environmental effects of chemical fertilizers and high cost (Gyaneshwari *et al.*, 2002). Through acidification, chelation, exchange processes, and the generation of gluconic acid, PSB might transform these insoluble phosphates into forms that plants could use (Chunget *et al.*, 2005; Gulati *et al.*, 2010). They may also stimulate plant growth by secreting hormones specific to plants, such as cytokinin and indole acetic acid (Sadaf *et al.*, 2009). The investigated phylogenetics is used to establish the historical relationships between several species or genes and to illustrate these relationships in the form of a branched tree known as a phylogenetic tree (Hillis, 1997). Using genome-based phylogenetic analysis, it is possible to understand the genetic changes responsible for the evolution of species. The objective of this study is to determine the effect of phosphate solubilising bacteria on the growth of tomato (*Solanum lycopersicum*) plant under pot conditions and to predict the genomic island of the isolated strain.

## MATERIALS AND METHODS

### Isolation of Phosphorus Solubilising bacteria and its morphological analysis

The roots of tomato (*Solanum lycopersicum*) plant and the immediate surrounding soil were collected in sterile sample bags from the field of SHUATS, Prayagraj, Uttar Pradesh. The phosphate solubilizing bacteria were isolated by suspending 10g of rhizosphere soil into 90ml of distilled water. Then, an aliquot of 0.1 ml of serially diluted



**Shipra Kumari**

rhizospheric soil suspension was inoculated on Pikovskaya's medium (pH 7.2) (Pikovskaya, 1948), and incubated at 37° C for 24-48 hrs. The colonies that produced clearing zones in the PVK agar plates were isolated, to study the cell morphology by using Gram staining(Coico, 2006).

**Preparation of Bacterial Broth Culture**

The bacterial colony was then inoculated in PVK broth after the analysis of morphological characteristics. Roots of the *Solanum lycopersicum var. pusa ruby* were dipped in the PSB broth of different concentration as shown in Table-1 and effect of PSB was determined in terms of various growth parameters which was height of plant, no of fruits per plant and weight of fruit per plant. A total of twenty-four plants that were planted, two tomato plants (*Solanum lycopersicum*) for each treatment were taken to see the effects of the phosphate solubilizing bacteria. The parameters for tomato plant growth were recorded from the initial time i.e., 15 days to the harvesting time i.e., 90 days. There were total 12 treatments of tomato plant with the phosphate solubilizing bacteria designated with T having numbers in subscript starting from T<sub>0</sub> to T<sub>11</sub>.

**Molecular Characterization**

The Genomic DNA, was extracted from the bacterial isolates by the kit method [Nucleo-pore Gdna Bacterial Mini Kit (Cat. NP-7006D)] according to manufacturer's instructions. Further, Agrose Gel Electrophoresis was done to confirm the presence of DNA. DNA quantification and quality determination was done by using UV Spectrophotometer. The PCR reaction mixture was prepared as per the contents mentioned in Table-2. Then, the reagents were combined in the 0.5 ml tube or in the 0.2 ml PCR tube followed by keeping the reagents on ice. Tube was tapped gently to mix or spined briefly in micro-centrifuge to get all contents to bottom, then placed on ice until ready to load in the thermo cycler. The tubes were then placed in thermal cycler and were subjected to 35 cycles in a thermal cycler with the following program: initial denaturation at 94°C for 3 minutes which was followed with 35-cycle consisting of denaturation at 94°C for 30 seconds, annealing at 60°C for 30 seconds, and elongation at 72°C for 2 minutes. The reaction was completed with an extension step at 72°C for 5 minutes.

Upon completion of PCR, the samples were kept at 4°C. Then, the DNA was prepared for loading by addition of 5µl gel loading dye with 6µl of PCR product. The product by Agarose gel electrophoresis on 1.2% gel was analyzed and the size markers in at least one well on the same gel were included. The amplification product was analyzed at 50 V and the gel was observed on trans-illuminator for the amplified bands in the middle of the gel. The sequence of the 16S rRNA amplified product was done by Sanger's Sequencing Method. The sequence obtained was further analyzed and identified using Bio informatic tools viz., BLAST program, Bio Edit and MEGA X. The sequences obtained in this study were examined using the BLAST algorithm to detect closely related bacteria by comparing a nucleotide query sequence against a public nucleotide sequence database (Yu *et al.*, 2011). The National Center for Biotechnology Information (NCBI) database was used for BLAST analysis on the 16S rRNA nucleotide sequences [www.ncbi.nlm.nih.gov/blast](http://www.ncbi.nlm.nih.gov/blast). The sequence with maximum percent identity was known to have maximum similarity with the query sequence were downloaded from the NCBI database. The identified species and the closely related species were then used to construct phylo genetic tree by MEGA X and sequence alignment is done by Clustal W, followed by Genomic Island Analysis(Bertelli *et al.*, 2019).

**Statistical Analysis**

All data in the present study were subjected to analysis of variance (ANOVA), F-cal and F-Tab were calculated on Excel sheet.

**RESULT AND DISCUSSION****Plate assay and staining**

The plates of the Pikovskaya's (PVK) medium that were cultured, resulted in the growth of bacteria forming colonies and producing halo zones surrounding it, which indicated that the phosphate in the media was solubilized as shown





**Shipra Kumari**

in Fig-1. The bacteria able to solubilize phosphate were determined when zones of clearance were observed surrounding the colonies. The halo zones formed is the product of solubilizing insoluble phosphate due to the release of organic acids in the media. The Gram staining results indicated that the bacteria were gram- positive rods as shown in Fig-2. Other than this, they were found singly which are the attributes of *Bacillus* species.

**Growth parameters**

The twenty-four plants treated with twelve treatments were observed for their growth, flowering and fruiting stage. The first parameter was the height of the plant. Among these, the treatment that was highly effective was T<sub>11</sub> with 91.50 cm plant height and the least effective treatment was T<sub>0</sub> with 79.50 cm plant height as shown in Table-3. Fig- 3 shows this data recorded in the form of a bar diagram plotted against height of plant in cm. The second parameter was the number of fruits per plant to determine vegetative growth of tomato plant. Among these, the treatment that was highly effective was T<sub>10</sub> with an average of 27.50 fruits per tomato plant and the least effective treatment was T<sub>0</sub> with an average of 18 fruits per tomato plant as shown in Table-4. Fig-4 shows this data, recorded in the form of a bar diagram plotted for 12 treatments against number of fruits per tomato plant. The third parameter was the weight of fruits per plant to determine vegetative growth of tomato plant. Among these, the treatment that was highly effective was T<sub>11</sub> with the fruit weight of 1193.50 gm and the least effective treatment was T<sub>5</sub> with the fruit weight of 567.50 gm as shown in Table-5. Fig-5 also shows this data, recorded in the form of a bar diagram plotted for 12 treatments against the weight of fruit in grams.

**Molecular Characterization**

According to 16S rRNA sequence analysis, the query sequence was found closely related to partial sequence of 16S ribosomal RNA gene of *Bacillus subtilis* strain NBRIYE1.3 with an accession number: MK168629 (Liu *et al.* 2015). In order to identify the bacteria from its query sequence as phosphate solubilizing bacteria on the basis of its 16S rRNA as well as phylogeny, phylogenetic tree as shown in Fig-6 was constructed using MEGA X.

**Bioinformatic analysis**

The species was identified as *Bacillus subtilis* as it was closest (on the adjacent branch in the phylogenetic tree) to *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence having accession no. MK168629.1. Four *Bacillus* species were selected for their Genomic Island (GIs) study are-*Bacillus subtilis* strain NCIB 3610, *Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5DNA, *Bacillus thuringiensis* Bt407. In the study we identified and analyzed GIs of antimicrobial resistance genes in the different strain of *Bacillus* including three pathogenic (*Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5 DNA and *Bacillus thuringiensis* Bt407) and one non-pathogenic (*Bacillus subtilis* strain NCIB 3610) species using Island Viewer 4. The results of the study showed absence of Genomic Island for Antibiotic resistant gene in *Bacillus anthracis* genome while other three organisms showed presence of GIs. Their presence was also marked by presence of high proportion of hypothetical proteins in this region as shown in the Fig-7 to Fig-13, encircled in RED, result of *Bacillus cereus* 03BB102 also shows presence of trans posases, which are the gene responsible for mobility and *Bacillus thuringiensis* Bt407 showed presence of integrase gene in the list marked by circle in GREEN. Integrase gene facilitates integration any new gene in the region as shown in Fig-9 and Fig-13.

**DISCUSSION**

Because soil phosphorus (P) is crucial for plant development, a lack of P restricts plant growth. Despite the addition of artificial fertilisers to the soils, plants might use phosphatic fertilizers sparingly and in small quantities. In this instance, choosing a highly effective PSB will essentially increase the amount of phosphorus in the plant rhizosphere (Zhang *et al.*, 2017). Therefore, PSB can be thought of as one type of rhizobacteria that promotes plant development and is frequently used as an alternative to typical biofertilizers. Establishing sustainable agriculture methods that could preserve the soil system's long-term ecological equilibrium is urgently needed. PSB are seen as one potential substitute for chemical fertilisers in this situation. Additionally, using the microorganisms as bio



**Shipra Kumari**

fertilizers for crop development will be considered a favourable signal of the presence of P-solubilizing microbial population in soils (Majeed et al., 2015). In the present research, soil samples from tomato plant's, rhizospheres were examined for the presence of PSB on Pikovskaya's medium. The different concentrations of isolated PSB broth showed positive effect on several growth parameters of plant such as height of plant, weight of fruit per plant, number of fruits per plant. The formation of organic acids and the acidification of the medium are the two main mechanisms involved in the solubilization of insoluble phosphate. The usage of phosphate solubilizing microorganisms has risen to improve the uptake of phosphorus as well as the yielding of crops because of their capacity to solubilize phosphate from phosphorus that are present in soil but inorganic in form (Khalid et al., 2004). Our results confirm that the phosphorous solubilizing bacteria can be isolated from immediate soil surrounding tomato plant. The effectiveness of the *Bacillus* spp. against the *Fusarium*-induced tomato plant wilt was examined in several researches. *Bacillus* species were found to be effective against fungus in agricultural fields in this investigation. They helped tomato plants grow more quickly as well (Ajilogba et al., 2013). Certain other species of *Bacillus* such as *Bacillus circulans* CB7 is responsible for increasing the solubilization of phosphorous and thereby increasing the growth of tomato plant by producing auxin. They improved roots' capacity for root development, which increased nutrient intake (Mehta et al., 2015). According to reports, the *Bacillus* species enhance the yield of spinach (Çakmakçi et al., 2007), sugarbeet (Çakmakçiet al., 2006), wheat (deFreitas, 2000), and maize (Pal, 1998). A similar increase in growth and P uptake of tomato plants due to inoculation of PSB strains was observed by (Poonia and Dhaka, 2012), (Turan et al., 2007). Numerous techniques are used to identify genomic islands, and they provide the organisms a certain distinguishing trait (Dobrindt et al., 2004; Vernikos and Parkhill., 2008).

The genomic island (GI) is part of a genome that has evidence of horizontal origins (Langille et al., 2010). Horizontal gene transfer has been recognized as a universal event throughout bacterial evolution (Hentschel and Hacker, 2001; Ochman, 2001; Ochman et al., 2000) and it is the primary mechanism for the spread of antibiotic resistance in bacteria (Gyles and Boerlin, 2014). In the study we identified and analyzed GIs of antimicrobial resistance genes in the different strain of *Bacillus* including three pathogenic (*Bacillus cereus* 03BB102, *Bacillus anthracis* CZC5 DNA and *Bacillus thuringiensis* Bt407) and one non-pathogenic (*Bacillus subtilis* strain NCIB 3610) species. The study's findings revealed that the genome of *Bacillus anthracis* does not have a genomic island (GI) for the antibiotic resistance gene, whereas the genomes of the other three organisms contained. They were also distinguished by the region's high concentration of fictitious proteins. From the present study, we demonstrate that the natural subtropical soil supports a diverse group of potential phosphate solubilizing bacteria. These P solubilizing soil bacteria could serve as efficient biofertilizer candidates for improving the P-nutrition of crop plants. The advantage of using natural soil isolates over the genetically manipulated or the one which has been isolated from a different environmental set up is the easier adaptation and succession when inoculated into the plant rhizosphere (Chen et al., 2006).

## CONCLUSION

Out of all the treatments, the best effect of treatment 11 was observed in the tomato plants. The highest plant height recorded was 91.5cm, the highest no of fruits recorded was 26.5, The highest weight recorded was 1193.50g. Molecular characterization analysis identified bacterial species as *Bacillus subtilis* as it was closest (on the adjacent branch in the phylogenetic tree) to *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence having accession no. MK168629.1. Upon the analysis of Genomic Islands (GIs), only *Bacillus anthracis* had the absence of Genomic Island for Antibiotic resistant gene, while other three strains (i.e., *Bacillus cereus*, *Bacillus thuringiensis* and *Bacillus subtilis*) showed the presence of GIs. The query sequence was uploaded on NCBI and accession number given was LC66322.1. The tested strains of *Bacillus* tend to enhance the growth of tomatoes (as measured by plant height, number of fruits per plant, and weight of fruits per plant). The selected *Bacillus* strains also enhanced the uptake of phosphorous by tomato plants and the available phosphorous content in the soil compared to the control. This study concluded that PSB can be used as a potential bio fertilizer to increase the growth and yield of the tomato plant. And will also help in minimizing chemical fertilizer application, reducing environmental pollution, and promoting sustainable agriculture.





Shipra Kumari

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### Shipra Kumari

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**Table-1 Concentration of PSB for the treatment**

S.No.	Treatment Name	Concentration of Treatment
1	T <sub>0</sub>	Control
2	T <sub>1</sub>	1%
3	T <sub>2</sub>	2%
4	T <sub>3</sub>	5%
5	T <sub>4</sub>	15%
6	T <sub>5</sub>	20%
7	T <sub>6</sub>	25%
8	T <sub>7</sub>	30%
9	T <sub>8</sub>	35%
10	T <sub>9</sub>	40%
11	T <sub>10</sub>	45%
12	T <sub>11</sub>	50%

**Table-2 PCR reaction mixture**

S.No.	CHEMICAL	STOCK	WORKING
1	Template DNA		5µl
2	PCR buffer	10x	2µl(1x)
3	dNTP	2.5mM	2.5µl (0.2 mM/L)
4	Primer	100 ppm	
	Universal forward primer		1µl (8 ppm)
	Reverse primer		1µl (8 ppm)





## Shipra Kumari

5	Taq polymerase	5U	1 $\mu$ l	
6	Distilled water		7.5 $\mu$ l	
	Total		20 $\mu$ l	

**Table-3 Effect of bacterial (PSB) treatment on plant height (in cm) of tomato after 15 and 90 days**

Treatment	Plant height (in cm)	
	Initial	Harvesting time
T <sub>0</sub>	19.50	79.50
T <sub>1</sub>	18.50	80.50
T <sub>2</sub>	17.25	81.00
T <sub>3</sub>	15.50	85.50
T <sub>4</sub>	17.75	86.00
T <sub>5</sub>	16.50	87.25
T <sub>6</sub>	20.00	87.50
T <sub>7</sub>	18.25	89.00
T <sub>8</sub>	19.00	89.50
T <sub>9</sub>	21.00	89.50
T <sub>10</sub>	15.75	91.25
T <sub>11</sub>	15.25	91.50
F-test	S	S
F-Tab	2.818	2.818
F-cal	7.202	4.005

**Table-4 Effect of bacterial (PSB) treatments on vegetative growth of tomato (number of fruits per plant) after 90 days**

S.No.	Treatments	Number of Fruits
1	T <sub>0</sub>	18.00
2	T <sub>1</sub>	20.50
3	T <sub>2</sub>	21.00
4	T <sub>3</sub>	21.00
5	T <sub>4</sub>	20.50
6	T <sub>5</sub>	22.50
7	T <sub>6</sub>	22.00
8	T <sub>7</sub>	21.00
9	T <sub>8</sub>	24.00
10	T <sub>9</sub>	25.50
11	T <sub>10</sub>	27.50
12	T <sub>11</sub>	26.50
13	F-cal	4.350
14	F-Tab	2.818
15	F-test	S

**Table-5 Effect of bacterial (PSB) treatments on vegetative growth of tomato (weight of fruits per plant in gram) after 90 days**

S.No.	Treatments	Weight of fruits (in gm)
1	T <sub>0</sub>	912.50
2	T <sub>1</sub>	990.00





**Shipra Kumari**

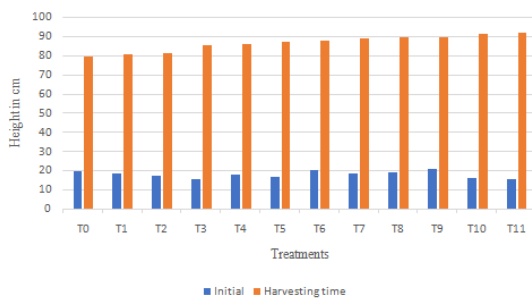
3	T2	950.00
4	T3	1002.50
5	T4	974.50
6	T5	567.50
7	T6	992.50
8	T7	959.00
9	T8	1087.00
10	T9	1147.50
11	T10	1085.00
12	T11	1193.50
13	F-test	S
14	F-Tab	2.818
15	F-cal	5.931



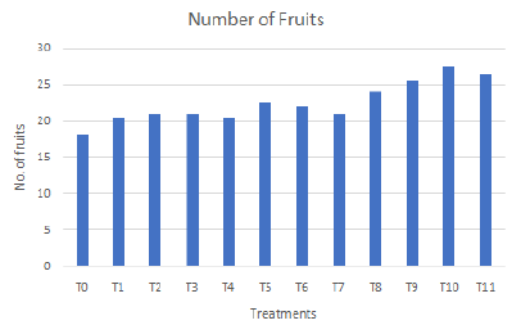
**Fig-1** PSB produced a clear halo zone around the colony in PVK media



**Fig-2** Isolate observed under 40X-magnification after gram staining, observed shape was rod and colour attained was crystal violet



**Fig-3** Effect of bacterial (PSB) treatments on height (in cm) of tomato plant after 15 and 90 days



**Fig-4** Effect of bacterial (PSB) treatments on vegetative growth of tomato (numbers of fruits) after 90 days







Shipra Kumari

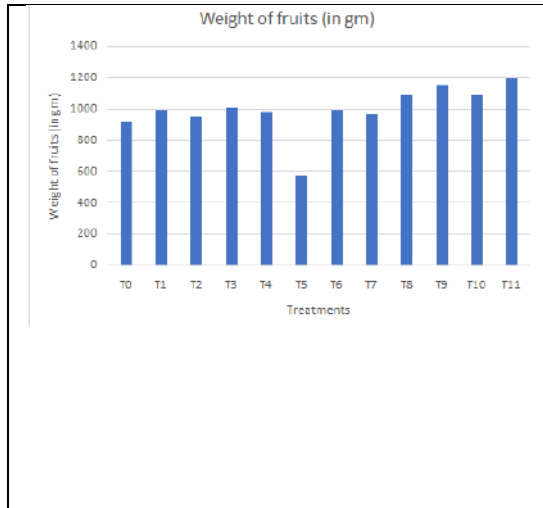


Fig-5 Effect of bacterial (PSB) treatments on weight of fruit (in gm) of tomato plant after 90 days

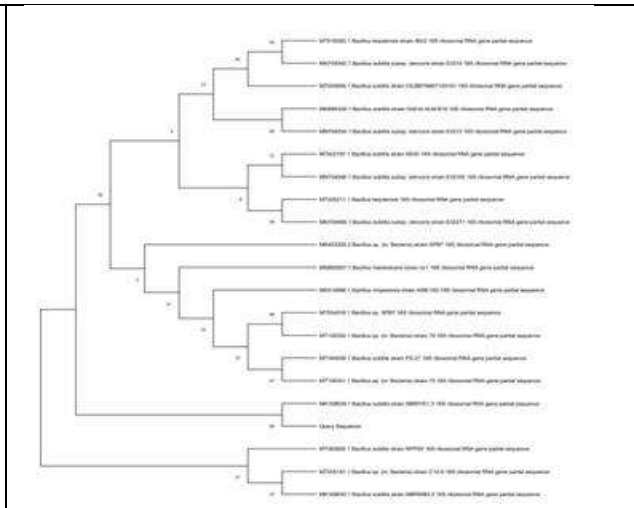


Fig-6 Neighbor-joining tree showing the phylo genetic relationships of query 16S rRNA gene sequences with the database sequences identifying *Bacillus subtilis* strain NBRIYE1.3 16S ribosomal RNA gene partial sequence having accession no. MK168629.1 as the closest homolog

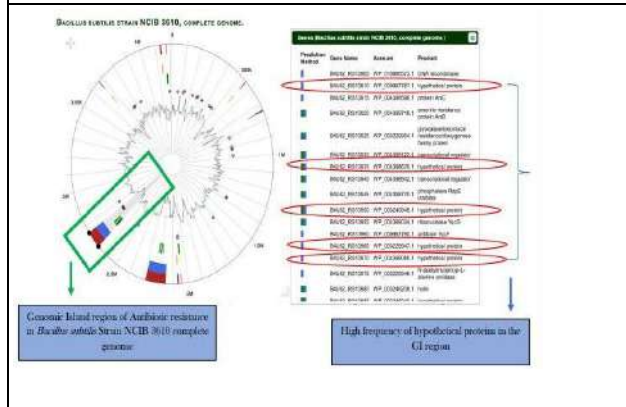


Fig-7 Results of Island Viewer 4 Prediction Tool, showing a circular representation of *Bacillus subtilis* strain NCIB 3610 complete genome with highlight on the resistance gene indicated by green box

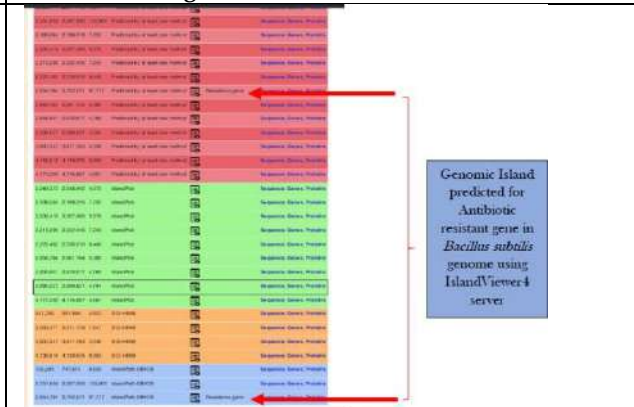


Fig-8 Results of Island Viewer 4 Prediction Tool result showing list of predicted genomic Island regions in *Bacillus subtilis* Strain NCIB 3610 complete genome







## Determination of Genotypic Pattern of $\beta$ -Case in Indian Local, Crossbred and Exotic Cattle

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### ABSTRACT

Most of human populations have long relied on milk from dairy cows as a high-quality source of protein and calcium. Numerous breeds of dairy cattle have been identified to have the beta- casein locus. Only position 67, which is histidine in A1 milk or proline in A2 milk, separates the A1 & A2 variations. During intestinal digestion, A1 milk is known to release the peptide betacasomorphin-7 (BCM-7). Which are associated with human heart disease, diabetes mellitus and Autism. A2-casein is typically regarded as safe for human consumption when choosing cows for increased milk yields and milk quality. Therefore, present research was conducted to determine pattern of genotypes (A1A1, A2A2 & A1A2) in our Indian local and Crossbred animal using PCR-RFLP techniques. 100 animals were genotyped for beta casein by PCR-RFLP techniques. 68 animals has A2A2 genotype where as 32 animals has A1A2 genotype. A2 variant of beta casein are most prevalent is studied population.

**Key words:** Cattle, Beta casein gene, A2 milk, PCR - RFLP.



**Shailja Vyas and Jenabhai Chauhan**

## INTRODUCTION

Cattle farming is essential for animal agriculture. The groups Bovidae and Bovinae, include domesticated cattle. There are 800 different breeds of cattle around the world [1]. Milk of cattle contains two types of milk proteins: caseins and whey proteins ( $\beta$ -lactoglobulin and  $\alpha$ -lactalbumin). Casein is the primary component of milk proteins secreted by mammary gland cells, accounting for approximately 80% of total milk protein [2]. Among caseins, beta casein, the second most abundant protein is the major resource of different bioactive peptides, mainly opioids. The structure and activity of bioactive peptides generated on digestion depend on the amino acid sequence (genetic variant) of protein which in turn is decided by the source of bovine milk. The  $\beta$ -casein gene (CSN2), which is situated on bovine chromosome 6, has a primary structure made up of 209 amino acids and a molecular mass varying from 23,946 to 24,097, according to the genetic variant [3]. Total of 15 genetic variants (A1, A2, A3, B, C, D, E, F, G, H1, H2, I, J, K and L) have been reported for beta casein ( $\beta$ -casein) gene [4]. Among these, the most common variants A1 and A2 are the most prevalent, whereas variants B, A3 and C are uncommon [5]. At position 67 of the beta-casein chain, A1 variant's has histidine whereas the A2 variant's has proline. This is due to exchange of a cytosine nucleotide with an adenine nucleotide [6].

Cow, buffalo, goat, sheep and camel are the principal sources of milk globally and their percentage contributions to the world/India's total annual milk production are 83.1/45.1, 12.8/51.2, 2.4/3.8, 1.4 and 0.3 respectively. Cows, as expected, contribute the most (81%) to global milk production, i.e. 600 million tons per year with a herd capacity of 1.002 billion (FAOSTAT 2020) [7]. India ranks first in total milk and third in cow milk (96 million metric tons) produced yearly [8]. Indian native cattle (20%), crossbred (28%) and exotic (1%) cattle contribute to milk production, with average milk yields of 3.90, 8.09, and 11.88 kg/day, respectively. Except for cattle, milk from all other dairy species and even humans contain the A2 allele of beta casein, which is the ancestral allele. The frequency of A1 and A2 alleles in cattle is breed dependent [9], and the *in vivo* release of BCM-7 from A1 milk/milk products is determined by the protein content of milk, which is similarly breed dependent [10]. Furthermore, these  $\beta$ -casein protein variants not only result in the generation of different groups of active peptides associated with negative health effects in humans [11], but also have an impact on milk protein composition and milk-production traits [12]. As a result, it is desirable to assess the frequency of not only A1/A2 variants but also "comprehensive haplotypes" constructed from changes observed in the coding and regulatory regions of the  $\beta$ -casein gene. The beta- casein CSN2-A1 variation has been linked to an increased risk of type diabetes [13-14] coronary heart disease and autism. CSN2-A2 lowers serum cholesterol and LDL lipid concentrations, which play a vital role in the prevention of a variety of human vascular diseases. Some epidemiological studies have linked CSN2-A1 consumption to an increased risk of cardiovascular disease (CVD) and type I diabetes in humans [15].

However, there is no documented record of CSN2 polymorphism in HF crossbred cattle or Gir cattle from Saurashtra, Gujarat. This information is required for the development of local cattle population selection and breeding plans. Therefore, the current study was done with the following goals in mind:

- I. To study the polymorphism in  $\beta$ -casein gene of Gir and HF crossbred cattle using PCR- RFLP technique.
- II. To study the relation between milk production, milk fat percent with various genotype of  $\beta$ -casein genes.

## METHODOLOGY

The study included 100 crossbred HF and Gir cattle from the Saurashtra region of Gujarat. The samples were collected from 2 organized (n=54) and 3 unorganized (n=46) farms. Blood samples were collected from each animal in EDTA tubes after getting consent from the farm owner.



**Shailja Vyas and Jenabhai Chauhan****DNA ISOLATION**

DNA isolation was accomplished using phenol-chloroform deproteinization and ethanol precipitation of bovine genomic DNA [16]. Blood samples of 10 mL were taken in EDTA- coated tubes. Proteinase K and digestion buffer were used to deproteinize the samples for 2 hours. Purification and isolation were accomplished using the phenol-chloroform process, and the resulting DNA was washed with 70% ethyl alcohol. The extracted DNA was kept at -20°C in 1X TE buffer. The absorbance ratio at 260/280 nm of isolated DNA was determined using a NanoDrop spectrophotometer.

**PCR Amplification**

Forward and reverse primers described by McLachlan (2006) were used for PCR amplification:

The sequence of forward primer is 5'- CCT TCT TTC CAG GAT GAA CTC CAG G-3' and the reverse primer sequence is 5'- GAT AAG AGG AGG GAT GTT TTG TGG GAG GCT CT-3'. A total volume of 25 µL was used for the PCR, which contained 20 ng/ µL (5 µL) DNA, 5.5 µL nucleus free water, 12.5 µL, 2X PCR master mix, 1 µL Forward primer and 1 µL Reverse primer. The following amplification parameters were used. Initial denaturation at 95°C for 5 minutes, followed by 30 cycles of denaturation 95°C for 40 seconds, annealing- 58°C for 60 seconds and Extension 72°C for 90 seconds. Ten minutes final extension at 72°C was performed [17].

**RFLP Analysis**

The CSN2 gene PCR amplicon was digested with *Dde* I restriction enzyme (NEB) for 3 hours at 37°C. The *Dde* I detects the C/TNAG sequence and produces fragments with 5'-cohesive termini. The success of restriction digestion of PCR products were assessed using 3% agarose gel containing ethidium bromide, followed by UV transilluminator analysis [18].

**STATISTICAL EVALUATION**

The POPGENE 32 version 1.32 software was used to calculate genotypic frequencies, allelic frequencies and to check Hardy-Weinberg equilibrium (HWE) [19].

**RESULTS AND DISCUSSION**

The current study found DNA absorbance ratio of 1.6 - 2.0 at 260/280 nm. DNA was quantified using the NanoDrop spectrophotometer. DNA Amplification using CSN2 gene specific primer reveal expected size (121 bp) PCR product in all the samples (Figure 1). PCR products digested with *Dde* I restriction enzyme shared 121,86 and 35bp in all the samples, indicated A1, A2 & A1A2 genotypes (Figure 2)

This result is concurrent with the previous study [12]. The RFLP pattern of DNA samples revealed that 70 samples have the A2A2 genotype, but the other samples do not. A1A2 genotype was found in 20 samples. After RE digestion, it was found that A1 allele was not digested and a fragment of 121 bp remained intact, however A2 allele was digested and revealed 2 pieces of 86 bp and 35 bp. The gene frequency of the A1 allele is 0.638 (63.8%) (Table 1), whereas the A2 allele is 0.362 (36.2%), which is compatible with the Slovak Spotted breed of cows [20]. They discovered the value of A1 and A2 allele frequencies 0.2928 and 0.7072, respectively. The increasing frequency of A1 allele in the current study could be attributed to purebred crossing. Previous study reports showed that 77% of dairy exotic breeds, including HF, possess A1A1 genes [19]. In this study, the observed percentage of A1A1 genotype is 0%, A1A2 genotype is 32.10%, and A2A2 genotype is 67.90% in local populations [21-22]. Comparative results of milk yield a fat percent with different genotype presented in table 2. There is no significant quantitative difference in both milk yield and fat percent in A1A2 and A2A2 genotyped animals.







Shailja Vyas and Jenabhai Chauhan

## CONCLUSION

The blood samples from 100 cattles were collected. The Quantification of DNA by NanoDrop spectrophotometer observed ratio of absorbance at 260/280 nm ranges from 1.40 to 2.03. The Quality of DNA were checked using 0.8% agarose gel electrophoresis, observed the sharp DNA band present in gel, indicated the Quality of DNA. Polymerase chain reaction of these sample were performed to identify the  $\beta$ - Casein PCR products (121 bp) in 2% agarose gel electrophoresis. PCR-RFLP analysis of *Dde I* digested PCR products on 3 % agarose gel electrophoresis indicated A1 or A2 Genotype. Our result suggests that CSN2 is polymorphic gene in local HF crossbreed and Gir cattle. More samples of Gir should be screened to assess the actual picture under field conditions concerning the prevalence of A1/A2 polymorphism. For breeding more A2 milk producing cows may significantly improve the public health, along with higher productivity.

## ACKNOWLEDGMENT

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**Shailja Vyas and Jenabhai Chauhan**

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**Table 1: Comparison of genotypes with milk yield and fat percent:**

Production trait	A1A2 genotype	A2A2 genotype
Milkyield (kg)	2719.237 +41.423	2769.116 +35.514
Fat %	3.613 +0.045	3.667 +0.037

**Table 2: Genotypes and alleles frequency of CSN2 gene**

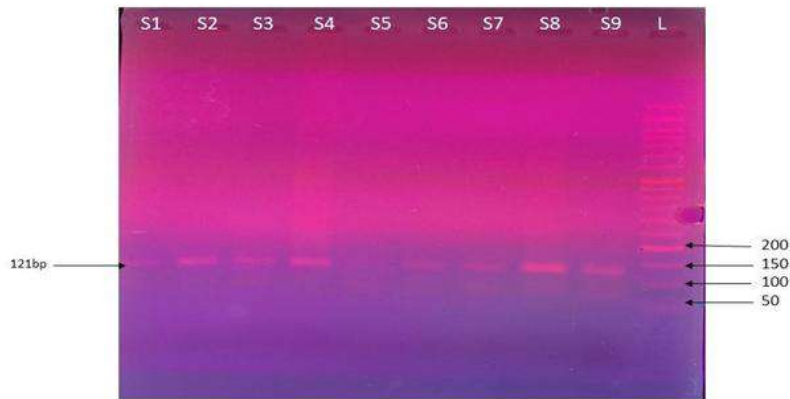
Genotypes		Gene/allele		$\chi^2$ test (HWE)	
A1A1	A1A2	A2A2	A1	A2	0.03
0.0	32.10	67.90	0.3617	0.6383	

HWE: Hardy-Weinberg equilibrium

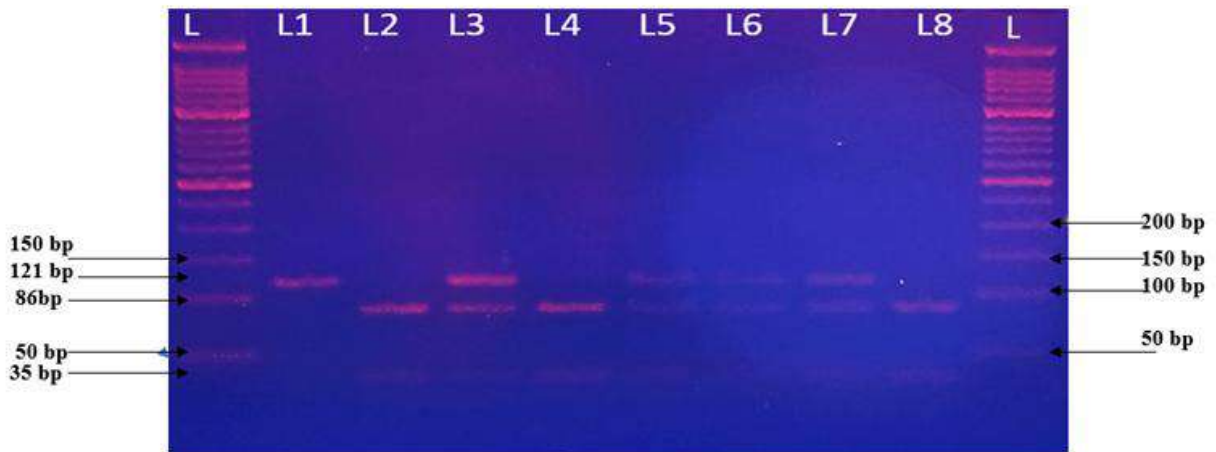




**Shailja Vyas and Jenabhai Chauhan**



**Figure 1: Electrophoresis analysis of PCR products (121 bp) of Beta casein gene of cattle. Lane L:50 bp Ladder, Lanes S1 to S9: PCR products (121bp).**



**Figure 2: Electrophoretic pattern of *Dde I* digested PCR products of representative samples on 3 % agarose. Lane 1&11: Low range DNA ladder (50 bp), Lane 2 : A1A1 genotype (121bp), Lanes 3, 5 and 9: A2A2 genotype (86 &35 bp) present. Lanes 4,6 and 8: A1A2 genotype (121,86 &35 bp). The small 35 bp fragments were invisible in the gel**





## PCOS Detection using Machine Learning Algorithms

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### ABSTRACT

Polycystic Ovary Syndrome (PCOS), is a hormonal disorder that occurs among women in their reproductive age. It has effective conflicts throughout this gynecological disorder, as it affects one in ten women at a nearly age. There are certain symptoms such as irregular menstrual cycles, missed periods, heavy bleeding during the menstruation period, excess of androgen hormones, obesity, acne or oily skin, hair growth on the face, and a typical weight gain. The exact cause of PCOS is not yet properly defined, but it could involve genetic causes and an imbalance in the diet. Due to certain effectiveness like the risk of heart attack, and type two diabetes, it is necessary to get detected and diagnosed as early as possible and start the possible treatments which include a healthy diet and exercises, with medications like birth control pills that control the level of hormones. Certain Machine Learning algorithms are used to detect this disorder. The data set consists of 541 patients, and out of 44 features, 10 potential features were identified using the filter method. This paper includes a detection model of PCOS using various machine learning algorithms like Random Forest, Logistic Regression, Support Vector Classifier, and Decision Tree. Among all these algorithms, Random Forest has 83.48% accuracy for the model.

**Keywords:** Polycystic Ovary Syndrome, Machine Learning, Random Forest, Logistic Regression, Support Vector Classifier, Decision Tree.

## INTRODUCTION

Technology is boosting its measure every single time which makes every transformation very flexible whether it is in the gadgets or the health care industry and services. Machine Learning plays a paramount role in all health-related domains as it is a constituent subset of artificial intelligence. There are distinct application areas such as image recognition, health monitoring, robotic perception, anomaly detection, and many more. It predominantly focuses on the development of algorithms that can be easily accessible from the data sets that are provided for detecting and predicting the required information. Thus, Machine Learning algorithms are utilized efficiently for the detection of PCOS. PCOS is a common hormonal disorder observed in women of child bearing age. Few symptoms indicate the





Diya Gandhi et al.,

hormonal balance, and it results in obesity associated with an enlarged polycystic ovary. In their productive age of 15-40, women experience their regular trend of their menstruation with hormonal effects, which shows that PCOS can affect individuals at any age. There are certain health risks due to this disorder including cardiovascular diseases which generally increase blood pressure and cholesterol levels, endometrial cancer occurs because the least ovulation leads to the build up of the uterine lining, mental health issues affect physiological conditions such as depression and anxiety, and type two diabetes happens due to insulin resistance and high blood sugar levels increase the risks of circumstances. The significant element in this heterogeneous condition is hormones. Luteinizing Hormone (LH), Follicle-Stimulating Hormone (FSH), and Anti-Müllerian Hormone (AMH) affect follicles and the development of the eggs, creating issues in ovulation, and FSH levels might be normal or lower than the usual values. Estrogens and Progesterone are essential for balancing the level of hormones to get the regular menstrual cycle. Among every suffering patient, 70% are undiagnosed. Hence, the prediction and detection of PCOS is necessary at the preliminary phase as it sustains the life of an individual by reducing lifelong health risks and creating a healthy life style.

The certain work focused in this paper is:

- I. Selection of the influential components affecting the patients of PCOS with the help of feature selection.
- II. Implementation of various machine learning algorithms on the selected features of the dataset. Comparing the accuracy of the different algorithms to fit the best model

## LITERATURE REVIEW

PCOS detection has become a hot topic for researchers in the last decade. Few individuals have implemented the various methodologies in this field to achieve the desired outcome for the health benefit to all women

This section consists of the distinct literature works done previously based on various implemented methods such as follicles detection, feature extraction, and classification, Cross Validation, Support Vector Machine (SVM), Logistic Regression, k nearest neighbors (kNN), and many more [4].

## METHODOLOGY

### Data Collection

Data collection is a crucial step. For this, various platforms are available example for Kaggle, UCI Repository etc. In this paper, we have used a dataset from Kaggle [1]. This dataset is composed of 44 different features with more than 500 records. Such features include pimples, hair growth, cycles, vitamin d3, etc.

### Data Preprocessing

Data Preprocessing is a step that takes raw data and transforms it into a format that can be understood and analyzed. Unprocessed data must contain some Missing values, Outliers, Unstructured manner, and Categorical data. Missing values can be corrected in many ways but the most common methods are Delete Rows with Missing Values and replace the missing value with some arbitrary value using fillna(), Missing values can also be imputed using 'interpolation'. Here we have also dropped unnecessary features. Furthermore, the dataset should only contain a value that is float or integer so that algorithms can process the data. The next step is Exploratory data analysis. This process involves summarizing, visualizing, and getting deeply acquainted with the important traits of a dataset. It examines a correlation matrix of all the features, and how all the features correlate with the PCOS, having a look at features bearing significant correlation.[4].

### Feature Selection

The feature selection method intends to select the most useful feature for a model to predict the output. Feature selection is performed to improve predictivity, reduce the dimensionality of feature space, and get rid of noisy data.





Diya Gandhi et al.,

Some favored techniques for feature selection are Filter Methods, Wrapper Methods, and Embedded methods. In this paper, we have used the filter method to rank each feature based on some univariate metric and then select the highest-ranking features and we have also referred to previous research to select the highest-ranking features [5].

#### **Fitting into models**

After the Data preprocessing, it is now ready to be handled by the models. Selected sets of features are used to study the algorithm. Among countless ML algorithms available, we have applied Logistic Regression (LR), Decision Tree Classifier, Random Forest Classifier, Gradient Boosting Classifier, and Support Vector Machine.

#### **Logistic Regression (LR)**

Logistic Regression, a supervised learning algorithm, uncovers its preliminary application in classification tasks by assessing the probability of a sample belonging to a distinct class. It is specifically fitted for binary classification, where the output variable is categorical. This algorithm operates the logistic function, also known as the sigmoid function, to convert the result of a linear equation into a value within the range of 0 to 1. This altered value represents the likelihood or probability of a data point being associated with a certain class. [11]. The accuracy of this algorithm was 82.56% here

#### **Decision Tree Classifier**

The Decision Tree classifier is a supervised algorithm principally operated for classification tasks. This technique operates by iteratively splitting the dataset into subsets according to the attribute values, resulting in a tree-like configuration. In this structure, individual inner node exemplifies a conclusion based on a distinctive characteristic, and each leaf node corresponds to a class label. Here, the accuracy of this algorithm was 77.98%. [12]

#### **Gradient Boosting Classifier**

Gradient Boosting is a significant boosting approach that assembles numerous weak learners into vital learners. This methodology involves training individually unique samples to minimize the loss function, such as mean squared error or cross-entropy, based on the performance of the previous model employing gradient descent. In each iteration, the algorithm computes the gradient of the loss function regarding the predictions assembled by the current ensemble. Thereafter, a unique weak representative is trained to minimize this gradient. The predictions yielded by the new model are incorporated into the ensemble, and this iterative approach persists until a predefined stopping criterion is satisfied. The accuracy here was 82.56% [12].

#### **Random Forest Classifier**

The Random Forest Algorithm is a supervised machine learning technique employed for addressing both classification and regression challenges in the realm of machine learning. It can be considered as an ensemble of decision trees. Instead of depending on a single decision tree, the random forest contains multiple decision trees, each prepared on distinct subsets of the delivered dataset. To enhance predictive accuracy, the algorithm computes the intermediate prediction from these trees. Instead of just depending on one tree's outcome, the absolute prediction is determined by a majority vote among the predictions from the ensemble of trees. The accuracy for this algorithm was 83.48%. [13]

#### **Support Vector Machine**

The Support Vector Machine (SVM) is a supervised learning algorithm appropriate for both classification and regression tasks, although it is primarily employed in classification problems in the field of machine learning. The primary objective of SVM is to establish an optimal conclusion limitation, usually directed to as a hyperplane, within an n- dimensional distance to effectively distinguish between different classes. This hyperplane relieves the proper categorization of further data attributes in the future. SVM identifies the critical data points that play a major role in determining this hyperplane; these pivotal representatives are known as support vectors, giving rise to the name "Support Vector Machine". The accuracy was 70% here. [14]





Diya Gandhi et al.,

### Evaluation and Comparison of Models

The comparison of these models is done based on accuracy. Various classification algorithms are used to find the most acceptable models. As shown in the table and plot the best accuracy is given by Random Forest Classifier, Gradient Boosting classifier, and Logistic Regression

## RESULT

The dataset contained 541 samples with 44 features. Out of these 44 parameters, only ten parameters are considered. Parameters that are more important for the diagnosis of PCOS are shown in Table III, after analyzing the performance of all five models, we can conclude Random Forest is most Suitable.

## CONCLUSION

This paper exhibits the different Machine Learning algorithms and a model to detect the early phase of PCOS, as it is essential for women's health. This hormonal disorder impacts the regular condition of women and disturbs the psychological, physical, and metabolic components. Day-to-day exercise and a regular healthy diet are initialized to decrease the effect and maintain a nourishing lifestyle. The model in this paper ventures the comfortable system to detect the disorder at an early stage, with a definitive set of parameters. Among all the various algorithms used, the Random Forest Classifier possesses the foremost result in its performance with 83.48% by considering the relevant 10 features. This model is flexible such that it can be utilized by doctors for the early detection of PCOS. Hence, we have built the model with different machine-learning techniques to detect PCOS at an early stage

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**Table 1. Research Methodology**

AUTHORS	OBJECTIVES	RESEARCH METHODOLOGY	RESULTS
Rihana et al. [2013] [2]	classification in ovary and Cysts detection, ultrasound images with geometrical features of the cyst.	Image pre-processing, Feature extraction, SVM classifier, and Validation were used by ROC.	Accuracy of 90% was achieved and cysts were detected in ovary ultrasound images.
Purnama et al. [2015][3]	Detecting follicles via ultrasound (USG) pictures through a process involving binary follicle images, feature extraction, and segmentation.	Multiple classification methods were developed such as SVM – RBF kernel, Neural Network – LVQ, and KNN – Euclidean distance.	At K=5, KNN attained an accuracy of 78%, and on C=40, 82% accuracy was achieved in the SVM-RBF kernel.
Denny et al. [2019][4]	Diagnosis of PCOS based on dataset available on Kaggle.	Attributes of PCOS are transformed with PCA by various machine learning algorithms such as Decision Trees, Random Forest, SVM, KNN, etc.	Random Forest was the best model for PCOS detection with an accuracy of 89%.
Subrato et al. [2020][5]	Diagnosis of PCOS using Kaggle dataset.	Algorithm used for classification are gradient boosting, Random Forest, Logistic regression, RFLR and used holdout and cross validation methods	RFLR gave highest accuracy of 91.01% with 90% recall value
Madhumta et al. [2021][6]	Used image segmentation to get details of the ovary for example follicle size, type of cysts.	SVM, KNN and Logistic Regression were used as per pre- processing and morphological operations.	With the combination of all three algorithm, the hybrid model gave 0.98 accuracy.
Pijush et al. [2021] [7]	Detection and prevention of PCOS.	The algorithm used were SMOTE and five other algorithms Logistic Regression, Random Forest, Support vector machine and K- NN, and Random Forest together for early detection of PCOS.	The best model achieved, Recall: 98%, Precision: 98% and AUROC: 95.6%.





**Diya Gandhi et al.,**

Shamik Tiwari et al. [2022] [8]	To diagnose PCOS using Machine Learning	The algorithms used for classification are SVM, DT, RF, LR, GB, AB, XB, AND CB for correlation coefficients of various levels.	Random Forest (RF) gave highest accuracy of 93.25%
Samia Ahmed et al. [2023] [9]	A review on the PCOS using the Machine Learning	A study on various dataset used for PCOS diagnosis was conducted. In quantitative and Qualitative approaches, the performance of algorithms are compared.	The shortcomings like insufficient dataset, lack of clustering approach, not were detected in this paper.

**Table 2. Accuracy of all Models**

Models	Accuracy
Logistic Regression	82.56%
Decision Tree Classifier	77.98%
Gradient BoostingClassifier	82.56%
Support Vector Machine	70%
Random Forest Classifier	83.48%

**Table 3. Selected Features**

Ranking	Features name	Value
1	FSH/LH	Between 1 and 2 (normal), 2 or 3 (abnormal)
2	FSH (mIU/mL)	4-8 (abnormal)
3	AMH (ng/mL)	1-4 (normal), >4 (abnormal)
4	BMI	<24 (normal), >24 (abnormal)
5	Weight gain (Y/N)	Yes(y)/No(n)
6	Follicle No. (L)	<12(normal) >=12(abnormal)
7	Follicle No. (R)	20-30(abnormal)
8	Avg. F size (L) (mm)	2-9 mm in diameter
9	Cycle	(Regular/Irregular)
10	Cycle Length	Number of days





Diya Gandhi et al.,

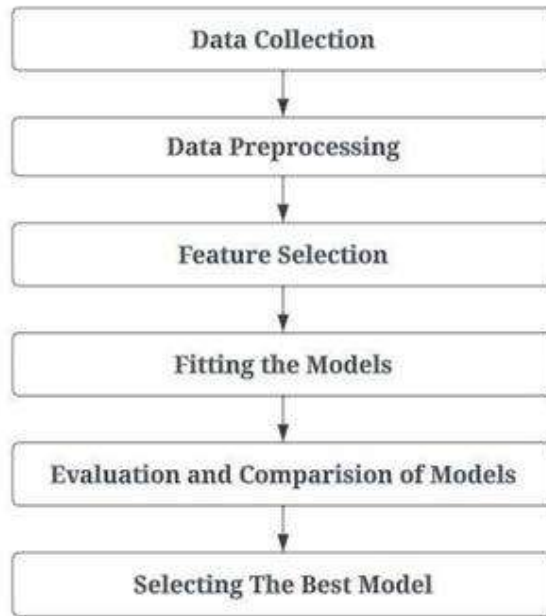


Fig I: System Flow of the Model

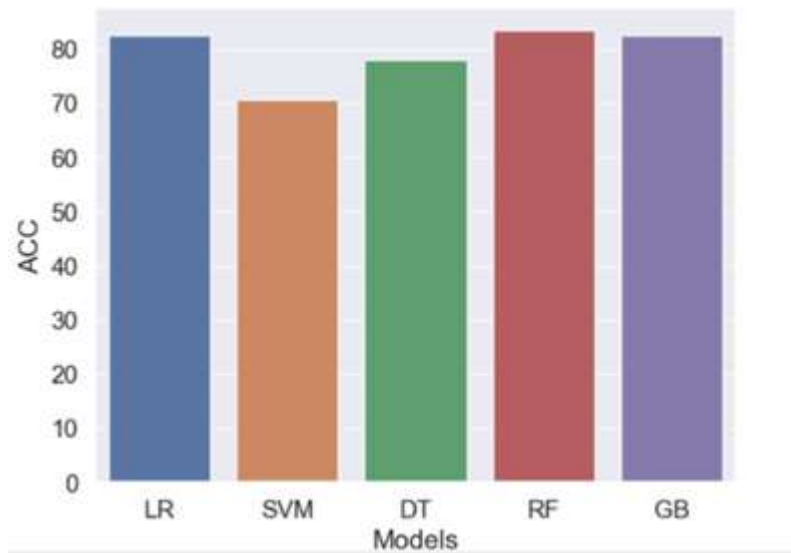


Fig 2.: Accuracy of all Models





## Evolving Horizons: Horn Antennas, SIW Advancements for 5G and their Pivotal Role in Satellite Communication

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### ABSTRACT

The evolution of satellite communication and 5G technology has brought significant advancement in antenna design and performance. This review paper delves into the multifaceted world of antenna technology, specifically focusing on Horn Antennas in satellite communication and Substrate Integrated Wave guide (SIW) Antennas in 5G applications. We explore the application of Horn Antennas in satellite communication, their benefits, and challenges. The main spotlight, however, is on SIW Antennas, highlighting their superior design, essential parameters, and the advantages that make them a preferred choice over traditional Horn Antennas. To exemplify the benefits of SIW Antennas, we closely examine the SIW H-Plane Horn Antenna, a compact marvel with increased gain designed for vehicular millimeter-wave communication. This paper aims to provide an insightful perspective on the prominence of SIW Antennas in modern communication technology and why they outshine traditional Horn Antennas.

**Keywords:** Horn antenna, satellite communication, Substrate integrated waveguide, 5G technology, Gain, Compact Antenna Design, Radiation Efficiency





## INTRODUCTION

In the ever-evolving landscape of communication technology, antennas play pivotal role in enabling the transmission and reception of signals. As satellite communication continues to bridge global connectivity, and 5G technology promises unprecedented speed and capacity, the demand for efficient and high-performance antennas has never been greater [1]. This review paper serves as a comprehensive exploration of antenna technology, with a primary focus on Horn Antennas in satellite communication and the transformative impact of (SIW) Antenna in their applications [4]. Horn Antennas in Satellite Communication: Satellite communication systems have long relied on Horn Antennas for their ability to efficiently radiate signals [3]. We delve into the applications of Horn Antennas in this domain, outlining their strengths, and examining the challenges they face when it comes to size, integration, and signal matching [1][2]. Substrate Integrated Waveguide (SIW) Antennas: The star of the show in this paper is the SIW Antenna, an evolutionary design that offers superior performance and flexibility [4]. We take an in-depth look at SIW's design principles, essential parameters, and explore the reasons behind its growing popularity over traditional Horn Antennas [9]. SIW H-Plane Horn Antenna: To illustrate the prowess of SIW Antennas, we zone in on the SIW H-Plane Horn Antenna, a compact wonder designed for vehicular millimeter-wave communication [6][8]. This antenna not only demonstrates increased gain but also symbolizes the future of communication technology. In a world where seamless connectivity and high-speed data transfer are paramount, understanding the evolution and advantages of antenna technology is critical. This review paper serves as a guide to comprehend the transition from Horn Antennas to SIW Antennas, shedding light on why SIW Antennas are taking the lead in the ever-expanding sphere of modern communication [20].

### TRADITIONAL HORN ANTENNA FOR SATELLITE COMMUNICATION

**Design** The compact antenna is designed incorporating an Ortho-Mode Transducer (OMT), mode converter, and a corrugated structure [1][3]. The compact OMT is designed to be fed by standard WR-75 waveguides. The design features only ten corrugated slots, which results in a symmetric radiation pattern [2].

**Operating Range** The antenna's impedance bandwidth (VSWR < 1.5) spans from 10.2 GHz to 15 GHz, making it suitable for both uplink and down link satellite communication in commercial systems [13].

**Performance** The proposed antenna achieves a gain between 14 dBi and 17 dBi, a constant 30-degree half-power beam width (HPBW) radiation pattern, and less than 9 mm phase center variation over the operating frequency range. The aperture diameter is 7 cm, and the total antenna length is 15 cm [3].

**Applications** The design is particularly suitable for use as a feed reflector in satellite communication systems due to its high gain, stable phase center, and compact form factor.

**Validation** The design is validated both numerically and experimentally. Experimental results demonstrate good agreement with simulation data.

**Comparison with Existing Designs** The paper compares the proposed antenna with existing designs, highlighting its competitive performance in terms of compactness, phase center stability, aperture efficiency, and low cross-polarization.

### SIW HORN ANTENNA OVER TRADITIONAL HORN ANTENNA

While traditional horn antennas have a well-established history of reliability and performance in satellite communication, the advent of Substrate Integrated Waveguide (SIW) horn antennas has introduced new possibilities and advantages [4]. The decision to opt for SIW horn antennas over traditional counterparts hinges on several crucial factors. Firstly, SIW horn antennas offer a substantial advantage in terms of compactness and integration [9]. As satellite technology evolves towards miniaturization, SIW horn antennas' planar and space-





Avinash Giri et al.,

efficient design makes them an ideal choice for modern satellite platforms where size constraints are paramount [11]. Their compatibility with planar technologies and materials, such as printed circuit boards (PCBs), lends itself well to integration with other RF and digital components, resulting in streamlined and cost-effective systems [5]. Moreover, SIW horn antennas exhibit excellent potential for emerging applications such as small satellite constellations and phased-array systems [7]. Their planar nature facilitates the construction of high-density phased arrays with multi-beam capabilities, making them essential for delivering high data rates in diverse directions. In addition to their adaptability to miniaturized systems, SIW horn antennas leverage the benefits of advanced manufacturing processes [10]. These antennas can be efficiently produced through batch fabrication techniques, ensuring consistency and affordability, which is essential in the rapidly evolving satellite communication industry. Furthermore, SIW horn antennas are known for their excellent radiation performance, low side lobe levels, and high front-to-back ratios, contributing to improved link quality and signal integrity [10]. The overall efficiency of SIW horn antennas is highly competitive, and their performance characteristics can rival or surpass traditional horn antennas under specific circumstances [5][9]. This means that SIW horn antennas can offer high gain and directional performance required for satellite communication while maintaining a smaller form factor [4]. While traditional horn antennas continue to serve as a dependable choice for satellite communication, SIW horn antennas provide innovative alternative with their compact design, integrative capabilities, manufacturing efficiency, and high-performance attributes [14]. The choice between these antennae technologies should be guided by the specific requirements of the satellite communication system and the broader design goals, ensuring that the antenna selection aligns with constraints and objectives of the mission [4].

#### ANTENNA STRUCTURE AND DESIGN

In this study, we have reviewed a horn-shaped Substrate Integrated Waveguide (SIW) antenna with specific dimensions. The antenna's width ( $W$ ) is set at 24.5mm, and its length ( $L$ ) measures 35.5mm. Figure 1 illustrates the geometric structure of the SIW-based horn-shaped antenna [20]. This antenna is designed with vias forming a horn-like shape and a line feed. We've printed the horn-shaped SIW antenna on a Rogers RT/Duroid 5870™ substrate, which has a thickness of 1.6mm and a dielectric constant ( $\epsilon_r$ ) of 2.33. This particular substrate, known for its low loss tangent, provides excellent performance characteristics in the Internet of Things (IoT) frequency range. The choice of frequency, substrate material, and antenna height depends on the specific application [11]. The dimensions of the vias and the spacing between them are determined by the following equations:

#### SIMULATION RESULTS AND DISCUSSIONS

In our simulations, we have evaluated the performance of the horn-shaped SIW antenna. Our findings are as follows

1. **Return Loss** The antenna exhibits a return loss of less than -10dB at several resonant frequencies, resulting in a broader band width [4].
2. **Voltage Standing Wave Ratio (VSWR):** The VSWR value remains below 2 for all resonant frequencies.
3. **Gain and Directivity:** The antenna demonstrates a gain of 6.9dB and a directivity of 7.0dB, as depicted in Figures 4 and 5, respectively.

Figure 2 [4] illustrates the return loss of the horn-shaped SIW antenna, revealing resonance at six different frequencies ranging from 23.2GHz to 27.5GHz, ensuring wide band matching for 5G applications. At 24.5GHz, the VSWR is an impressive 1.07, as shown in Figure 3. [4] We have also explored the impact of different substrates on antenna performance. In addition to Rogers RT/Duroid 5870, we considered substrates such as FR4 EPOXY, NELTEC NY9220 (IM), ARLON AD255C, and ASTRA ISOLA MT77. All these antennas were meticulously designed and simulated using HFSS. A comparison of antenna parameters based on different substrates is presented in Table 2.







Avinash Giri et al.,

## CONCLUSION

As we conclude our exploration of horn and SIW antennas in the realm of satellite communication and 5G technology, it is clear that the transition towards SIW antennas is driven by the need for smaller, more efficient, and highly integrated solutions. SIW antennas have proven themselves as formidable contenders, offering an array of advantages over traditional horn antennas. The future scope of SIW horn antennas is promising. With ongoing advancements in materials, manufacturing techniques, and the continuous evolution of 5G technology, SIW antennas are poised to become even more efficient and compact. Their adaptability to diverse applications, from satellite communication to terrestrial 5G networks, positions them as critical components of the modern wireless communication infrastructure. Looking ahead, we anticipate further breakthroughs in SIW antenna technology, enabling them to address the ever-growing demands of wireless communication. As the world becomes increasingly connected, compact, high-performance antennas like SIW horns will play a pivotal role in shaping the future of communication.

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Avinash Giri et al.,

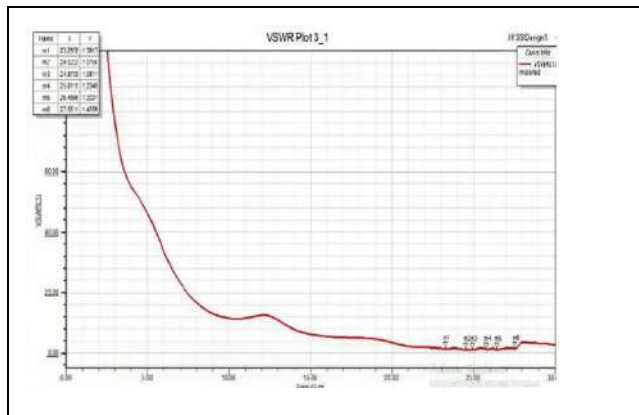


Fig 3. VSWR Plot

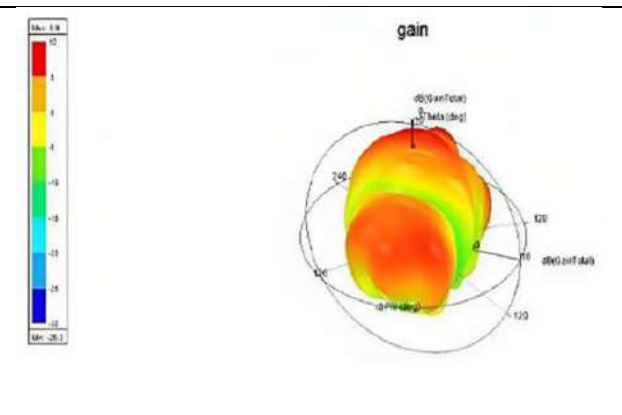


Fig 4. Gain plot for siw horn antenna [4]

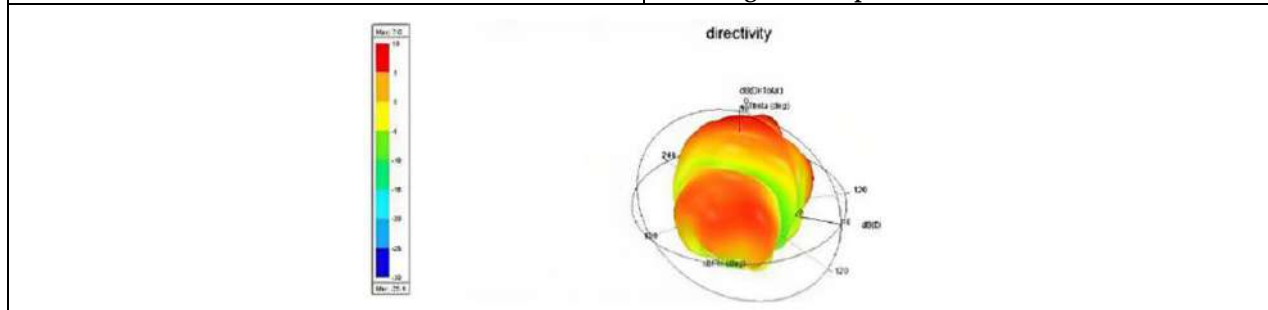


Fig 5. Directivity plot for siw horn antenna [4]





# A Study on Evaluating the Effectiveness of Environmental Education in Achieving SDGs

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## ABSTRACT

The intricate relationship between environmental education programs and attitudinal changes is a critical aspect of assessing their overall effectiveness in contributing to Sustainable Development Goals (SDGs). The challenges of integrating environmental education into formal systems require closer scrutiny of barriers and facilitators for effective implementation. This research will focus on evaluating attitudinal changes among participants who have undergone specific environmental education programs. Secondly, the study's findings can inform educators, policymakers, and stakeholders about the effectiveness of current approaches in fostering a sense of environmental stewardship. The positive correlation between community engagement and environmental education further emphasizes the potential of these initiatives in contributing to the achievement of SDGs, particularly SDG 15.

**Keywords:** SDGs, stakeholders, environmental education, policymakers,

## INTRODUCTION

The intricate relationship between environmental education programs and attitudinal changes is a critical aspect of assessing their overall effectiveness in contributing to Sustainable Development Goals (SDGs). As the global community strives to address pressing environmental challenges, understanding how educational initiatives shape individuals' values and perspectives becomes paramount. This study aims to delve into the attitudinal



**Jithin Scaria and Rinku K Vithayathil**

transformations resulting from participation in environmental education programs, seeking insights that can inform the optimization of these initiatives for enhanced impact on SDGs.

**Objectives of the Study**

1. Assess the Impact of Environmental Education Programs on Knowledge Acquisition
2. Examine Attitudinal Changes Resulting from Environmental Education
3. Evaluate Behavioural Changes and Sustainable Practices Adoption

**Statement of the Problem**

Despite the acknowledged impact of environmental education programs in achieving Sustainable Development Goals (SDGs), a critical gap exists in understanding the specific attitudinal changes they prompt among participants. While existing literature emphasizes knowledge acquisition and behavioural shifts, there is a lack of focused exploration into how these programs shape attitudes towards environmental conservation and sustainability. The challenges of integrating environmental education into formal systems require closer scrutiny of barriers and facilitators for effective implementation. This study aims to address this gap by examining the role of attitudinal changes in realizing SDGs, particularly SDG 4 and SDG 15. Through this exploration, the research seeks to provide targeted insights that can optimize environmental education initiatives for more effective contributions to sustainable development.

**SCOPE OF THE STUDY**

This research will focus on evaluating attitudinal changes among participants who have undergone specific environmental education programs. The scope encompasses diverse demographic groups, including varying age ranges, educational backgrounds, and levels of environmental awareness. The study will explore the nuanced shifts in participants' attitudes towards environmental conservation, sustainability, and their sense of responsibility in the context of SDGs, particularly SDG 4 and SDG 15. To provide a comprehensive analysis, the research will consider both formal and informal environmental education settings, encompassing a range of program types and delivery methods.

**SIGNIFICANCE OF THE STUDY**

Understanding the attitudinal shifts resulting from environmental education programs is pivotal for several reasons. Firstly, it provides empirical evidence of the programs' impact, aiding in the refinement and development of future initiatives. Secondly, the study's findings can inform educators, policymakers, and stakeholders about the effectiveness of current approaches in fostering a sense of environmental stewardship. Moreover, this research holds significance in contributing to the broader discourse on the role of education in achieving sustainable development, aligning with the global commitment to SDGs.

**RESEARCH METHODOLOGY****Participants**

The study will involve participants who have completed environmental education programs, drawn from diverse backgrounds and settings. A purposive sampling technique will be employed to ensure representation across age groups, educational levels, and program types.

**Data Collection****Surveys/Questionnaires**

A structured questionnaire will be administered to participants to collect quantitative data on attitudinal changes.



**Jithin Scaria and Rinku K Vithayathil****Data Analysis****Quantitative Analysis**

Percentage Analysis, Statistical tools, such as descriptive statistics and inferential tests, will be employed to analyse survey responses and identify patterns in attitudinal changes.

**LIMITATIONS OF THE STUDY**

Potential limitations may include self-reporting bias, variations in participant interpretation, and the influence of external factors not controlled by the study.

**REVIEW OF LITERATURE**

Martinez and Johnson (2020) highlights that environmental education interventions contribute significantly to attitudinal changes. Positive shifts in values, attitudes, and a heightened sense of responsibility towards environmental stewardship have been observed among participants who engage in comprehensive environmental education programs. Smith et al., 2018; Jones & Brown, 2019) consistently emphasize the positive impact of environmental education programs on knowledge acquisition and heightened environmental awareness. Participants often exhibit increased understanding of ecological systems, climate change dynamics, and the interconnectedness of human activities with the environment. Garcia and Nguyen (2019) investigates the obstacles and challenges faced during the implementation of environmental education programs. Identified barriers include resource constraints, institutional resistance, and societal factors, underscoring the need for tailored strategies to overcome these hindrances.

**FINDINGS**

1. The majority of participants reported a moderate to high level of environmental awareness before joining the program.
2. A significant proportion of participants expressed a moderate to extreme positive influence on their awareness of environmental issues.
3. A considerable number of participants reported moderate to extreme shifts in values and perceptions regarding environmental conservation and the interconnectedness of human activities and the environment.
4. A noteworthy percentage of participants indicated a moderate to extreme sense of responsibility towards environmental stewardship after completing the program. Likewise, many expressed a likelihood of engaging in sustainability-promoting activities in their communities.
5. Participants provided diverse and insightful comments, with some expressing the transformative nature of the program on their attitudes towards environmental issues.

**SUGGESTIONS**

1. Acknowledge the baseline awareness of participants and explore advanced content or experiential learning opportunities to challenge and deepen existing knowledge.
2. Highlight and emphasize program components that fostered these value changes, aiming to strengthen these elements for future program iterations.
3. Recognize the positive impact on participants' sense of responsibility and community engagement. Encourage and facilitate opportunities for participants to translate their newfound commitment into actionable initiatives within their communities.





**Jithin Scaria and Rinku K Vithayathil**

## CONCLUSION

The existing body of work underscores the pivotal role of these programs in cultivating a sense of environmental responsibility and fostering sustainable practices. The positive correlation between community engagement and environmental education further emphasizes the potential of these initiatives in contributing to the achievement of SDGs, particularly SDG 15. However, the literature also highlights challenges, such as the need for effective integration into formal education systems and addressing barriers to implementation. As this study embarks on evaluating the effectiveness of environmental education programs, it aims to build upon existing knowledge, providing nuanced insights into the attitudinal transformations among participants. By doing so, this research endeavours to contribute evidence-based recommendations for optimizing the impact of environmental education in the pursuit of sustainable development goals.

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