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The journal has provided an opportunity and space to the Crossian scholars, Professors and research guides of our institution and other institutions at national and international levels. This little, yet, vibrant reverberation of intellectual sharing will definitely generate new knowledge and ignite and unleash power to re-search within the visionary researchers.

Crossian Resonance strives to keep up the standard from the first issue and all the papers published in this issue were assessed by competent referee editors and were recommended for publication. This journal is committed to the development and regeneration of the nation with the scope of providing an open and common platform to launch a united vision and empowerment of innovative knowledge.

May this endeavour grow and remain evergreen like an olive tree to create renewed awareness, dimensional consciousness and enlightenment.

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CONTENTS

1	Electronic Band Structure, Density of States and Metallization of Alkali Iodides A. Jafrin Ashima, X. Malkija Romel, R. S. Nanthini and C. Nirmala Louis	1
2	Synthesis and Characterization of Tin Oxide (SnO ₂) Nanoparticles A. Remila, J. S Finibhajebal, J. Selciya and V. Shally	8
3	Hydrothermal Assisted Synthesis of CuO-Mn ₂ O ₃ and CuO- Fe ₂ O ₃ Nanocomposites: Structural and Optical Characterization J. Aji Alan Femi, A. Antony Arokya Sangeetha Devi, J. Jenima, J. Jasma Shalu, E. J. Vishaka and M. Priya Dharshini	13
4	Structural and Optical Properties of ZnO-Mn ₂ O ₃ and ZnO-MgO Nanocomposites synthesized by Co-precipitation method S. B. Dharrsana, J. Jasmashalu, J. Jenima, Antony Arokya Sangeetha Devi, E. J. Vishaka and M. Priya Dharshini	19
5	CdO-MgO and CdO-Fe ₂ O ₃ Nanocomposites: Ultrasonication Assisted Synthesis and Characterization R. Fathima Naseeha, J. Jenima, J. Jasma Shalu, Antony Arokya Sangeetha Devi, E. J. Vishaka and M. Priya Dharshini	24
6	Enhanced Properties of Orange Peel Imposed Epoxy Composite M. S. Mallika, R. Asmitha, M. Herin, S. Jasvy, M. Merisha, S. Virgin Jeba, S. Sebastiammal and A. Lesly Fathima	30
7	Physico-Chemical and Thermal Analysis of Sodium Acetate Treated Cocos nucifera Fibres S. Anne Kavitha, S. Subi, J. Mridula Pearly, V. Sahaya Reena and R. Krishna Priya	38
8	Single step synthesis of Copper Oxide Nanoparticles: A study on structural, optical, thermal properties and antibacterial effectiveness S. Suji, Y. Julit, J. Jershma, M. Abila Jeba Queen and P. Aji Udhaya	45
9	Synthesis of Nickel Hydroxide [Ni (OH) ₂] Thin Film using SILAR Method C. Anslin Jhony, A. Ahashine and S. Sonia	55

10	Development of Nickel Oxide Nanospikes Using Sol-Gel Method M. Keerthika, A. Fathima Arshi, A. Lesly Fathima, S. Sonia and S. Virgin Jeba	61
11	Copper Ferrite Thin Film Fabricated using the Doctor Blade Method: Synthesis and Characterization S. Anni Ranisha, J. Jenisha, G. Mary Griffika, P. Aji Udhaya and M. Abila Jeba Queen	66
12	Synthesis and Characterization of Hydroxyapatite from Eggshell with <i>Carica papaya</i> Leaf Extract J. Jelina Jedly, M. Steny, Krishna Veni, A. Lesly Fathima and S. Sebastiammal	72
13	Synthesis of Cobalt-Oxide Nanoparticle using Co-Precipitation Method C. Nishitha, R. Jenisha, S. Sonia and S. J. Jenepha Mary	79
14	Synthesis and Characterization with Antibacterial and Antifungal Activity Studies on some Transition Metal Complexes of N, O Donor Novel Schiff Base Ligand S. Ajith Sinthuja and Y. Christabel Shaji	84
15	Green Synthesis, Characterization and Antimicrobial Activity of Cobalt Oxide NPs obtained using <i>Cassia occidentalis</i> Plant Extract L. Deva Vijila and M. Antilin Princela	92
16	Evaluation of Antioxidant and Antidiabetic Potentials of Aldimine synthesized from Vanillin and Aniline using <i>Malpighia emarginata</i> Fruit Extract J. Gincy Priya and Sheeba Daniel	99
17	<i>Cocos nucifera</i> Husk-Based Silver Nanoparticles for Antimicrobial Studies S. Sabadini, A. H. Hatin Betseba, J. B. Aashmi Farrell, R. Haritha, J. Jenifa Heartlin, J. Venus Prabisha and Y. Christabel Shaji	107
18	α -Cyclodextrin Complexation - A Viable Route to Taste Masking of Bitterness of Chloropheniramine Maleate S. Lizy Roselet, M. Shirley Treasa, M. Antilin Princela, B. T. Delma and K. Francy	114

19	Preliminary phytochemical analysis and antibiogram of the seagrass <i>Syringodium isoetifolium</i> (Asch.) Dandy collected from Kooduthalai Coast, Tirunelveli. J. Jenifer and F. Brisca Renuga	123
20	Antibacterial activity of the tissue extracts of Marine crab, <i>Lauridromia dehaani</i> I. Nisolin Rajee, A. Anu Flowercy, A. Sahaya Mini, J. Varshini, A. Vinnarasi and A. Punitha	130
21	Anisotropic Diffusion-Based Image Processing for Brain Tumour Detection using Partial Differential Equations C. M. Jenifer Christina, T. Sheeba Helen and V. Sujin Flower	138
22	The Domination Uniform Subdivision Number of Total Graphs T. Berjin Magizha and M. K. Angel Jebitha	148
23	An Optimal Solution of a Fuzzy Linear Programming Problem K. Roshika and J. C. Mahizha	156
24	Relatively Prime Domination in Discrete and Ascending Topological Graphs A. Anat Jaslin Jini and A. Jancy Vini	164
25	2-Dominating Sets and 2- Domination Polynomial of Paths P. C. Priyanka Nair	172
26	Modified Wiener Index and Modified Hyper Wiener Index of a Nanorod Graph S. Sobiya and S. Sujitha	180
27	A Study on Srivastava and Singh's Refined Arithmetic Model of Fuzzy Time Series Forecasting S. Imalin, V. Anithakumari and V. M. Arul Flower Mary	188
28	Edge Domination in Fuzzy Magic Graphs R. Maria Anushiya J. Befija Minnie and A. Jancy Vini	197
29	Implementation of Neural Network Algorithms in AI Based Pattern Recognition B. Ancie Moul and F. Fanax Femy	202
30	Inscriptions and Copper Plates of Nellaiyapper Temple at Tirunelveli - A Study K. Baby	211

31	Tourism Development through the Lemur Beach in Kanyakumari District S. Mary Judit	218
32	A Study on Pradhan Mantri Awas Yojana Gramin in Kanyakumari District S. Panimaya Mercy	229
33	Central Bank Digital Currency and its Implications for the Monetary System Sofista Manuel and A. Sameema	242
34	A Study on Socio-Economic Condition of Aari Workers in Nagercoil Corporation of Kanniyakumari District M. Afrin and A. Babila Kingsly	250
35	Customer Awareness and Application of Green Banking Practices N. Saromi and S. Sahayaselvi	255
36	From Silence to Resilience: Breaking the Boundaries of Suppression in The Woman Warrior by Maxine Hong Kingston P. Jasmine Serina and H. Jimsy Asha	266
37	Breaking Bond: A Portrayal of Familial Relationship in Jeannette Walls's The Glass Castle A. R. Jemi and M. F. Anne Feril	274
38	Cancer Journey and Tenacity of Yuvraj Singh in the Novel The Test of My Life Ryan Antony and Selva Mary Gokila S. George	277
39	Voice of an Unsung Heroine: A Study of Madline Miller's <i>Circe</i> K. B. Steffi and J. Bhavani	279
40	Sufferings and success story of Rahima: A Critical Study of Nadia Hashimi's The Pearl That Broke its Shell V. J. Maxlin and J. Bhavani	283
41	Significance of Women and War in Kate Quinn's The Alice Network G. K. Ditty Geo and C. Nesavathy	287
42	Exploring the Narrative Techniques in Paulo Coelho's The Devil and Miss Prym M. Ihshana Fathima and V. Virgin Nithya Veena	293

43	Dark Humour and Meta Irony: A Stylistic Reading of Jeremy Robert Johnson's The Loop P. Sherena and V. Virgin Nithya Veena	298
44	Quest for Companionship in Dogs: A Psychological Analysis of Stephen Foster's Walking Ollie J. Shanu Joans and V. Virgin Nithya Veena	305
45	The Role of Translation in Promoting Multilingualism P. T. Anbu Hannah Dora	309
46	இயற்கையில் இன்புற்ற இலக்கிய மாந்தர்கள் செ. தேன்மொழி	313
47	வல்லறம் விரும்பா குறளறம் வ. ஆன்றனி பிரகாஷ் பபிலா	317
48	கயமனாரின் இயற்கைக்காட்சியும் உவமைநலனும் மா. தே. அருண் மொழி நங்கை	322
49	சங்ககாலத் தமிழரின் கடல் வாணிபம் சி. ஆன்சிமோள்	330
50	தமிழ்க் கவிதைகளில் பெண்கள் சா. டெய்சிபாய்	338

Electronic Band Structure, Density of States and Metallization of Alkali Iodides

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ABSTRACT

The pressure dependent band structures, density of states and total energies of alkali iodides are calculated and used the result to study the metallization under pressure. The metallization pressure for NaI, RbI, CsI were 13.37 Mbar, 12.62 Mbar, 8.5106 Mbar. The relation between lattice constant and pressure, pressure and band gap, reduced volume and lattice constant, reduced volume and pressure, band structure and density of states were drawn.

Keywords: Alkali Iodides, Band Structure, Metallization Pressure.

1. Introduction

Currently there is a lot of interest in the high-pressure behaviour of materials. The physical properties of materials undergo a variety of changes when they are subjected to high pressure. The increase of pressure means significant decrease in volume, which results in the change of electronic states and crystal structure. With the development of high-pressure experimental techniques, investigations on pressure-induced structural phase transition, semiconductor-metal transition and superconducting transition are getting the attention of all [1,2]. For example, the ionic salt CsI is a metal under high pressure. [3,4,5] In the present paper, we give more extensive discussion about the band structure and density of states. The metallization is investigated and analyzed.

2. Band Structure and Density of States

2.1 At Normal Pressure

The normal pressure band structure of alkali iodides is given in Fig.1, 2, 3. The overall topology of the band structure at $V/V_0=1$ is same for previous calculation.

In NaI, the three bands appearing just below the Fermi energy E_F are from Na-3s¹ and I-5s², 5p⁵ electrons of NaI (Fig. 1). The empty conduction bands above the Fermi level are due to 3p⁰, 3d⁰ states of Na and 5d⁰, 6s⁰, 6p⁰ states of I (Fig.1). At normal condition, the band gap E_g is found to be 0.2480Ry (3.373 eV) for NaI. The general features of band structures are

similar to previous calculations. From our calculation, NaI is a direct band gap insulator at normal pressure.

The density of states histogram of NaI at normal pressure is given in Fig. 4. From the histogram, it is seen that at normal pressure the short spikes near E_F are due to Na-3s1, I-5p5 electrons (Fig. 4). The short spikes above the E_F are due to the $3p^0$, $3d^0$ and $5d^0$, $6s^0$, $6p^0$ states of NaI. At normal density of states histogram, the band gap E_g is found to be 0.2480 Ry (3.373 eV) for NaI. This value is agreement with the experimental value of 3.36 eV. The general features of density of states are similar to previous calculations.

The band structure and density of states for RbI, CsI occur in the same manner at normal pressure.

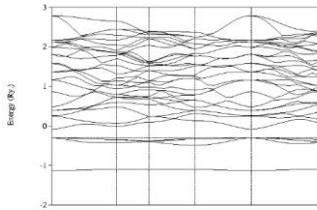


Fig.1: Band Structure of NaI at V/V o=1

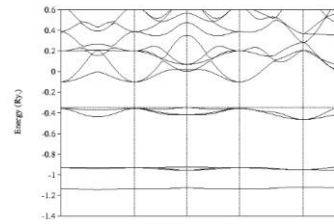


Fig.2: Band Structure of RbI at V/V o=1

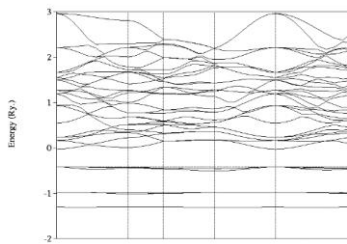


Fig.3: Band Structure of CsI at V/V o=1

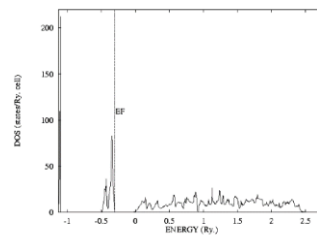


Fig.4: DOS of NaI at V/V o=1

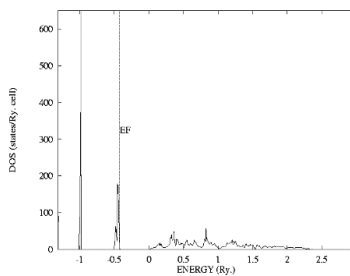


Fig.5: DOS of RbI at V/V o=1

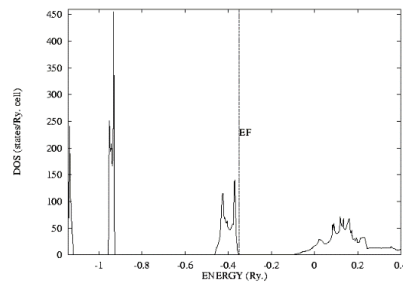


Fig.6: DOS of CsI at V/V o=1

2.2 At High Pressure

When pressure increases, the value of E_F and density of states at E_F increases. The band structure and density of states of NaI (for CsCl structure) RbI (for CsCl structure), and CsI (for HCP structure) corresponds to metallization pressure =13.3726 Mbar, 12.62 Mbar, 8.5106 Mbar respectively are given in Fig 7, 8, 9. Fermi level is indicated by dotted horizontal line.

In case of NaI the triplet bands which are positioned at the bottom of valence band arise 3s1 electrons of Na (Fig. 7). A single band nearer to the triplet bands is due to I-5s2 electrons.

The three bands appearing just below the Fermi energy E_F and touching Fermi energy E_F are from Na-3s1 and I-5p5 electrons of NaI. The unfilled conduction bands above the Fermi level are due to 3p0, 3d0 states of Na and 5d0, 6s0, 6p0 states of I. Density of state calculations for all the reduced volumes have been carried out, but the histograms are given only for, $V/V_0 = 0.2282$ in case of NaI (Fig.10), $V/V_0 = 0.2004$ in the case of RbI (Figs.11), and $V/V_0 = 0.247$ in case of CsI (Fig.12).

For NaI the levels arising from Na-3s1 (Fig. 10) electrons give a longest spike with fine width. The extended spike near the origin is due to I-5p5 electrons and the dumpy spikes near E_F are due to Na-3s1, I-5p5 electrons. The petite spikes above the E_F are due to the 3p0, 3d0 and 5d0, 6s0, 6p0 states of NaI.

The band structure and density of states for RbI, CsI occur in the same manner at metallization pressure.

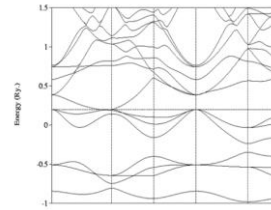
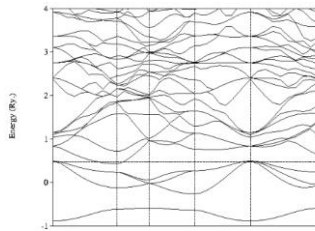


Fig.7: Band Structure NaI at Metallization Fig.8: Band Structure of RbI at Metallization

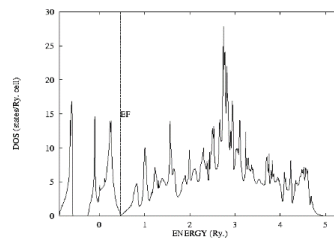
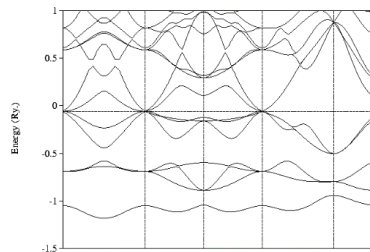


Fig.9: Band Structure of CsI at Metallization

Fig.10: DOS of NaI at Metallization

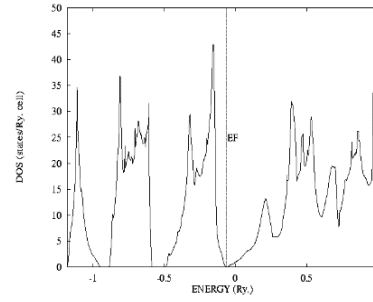
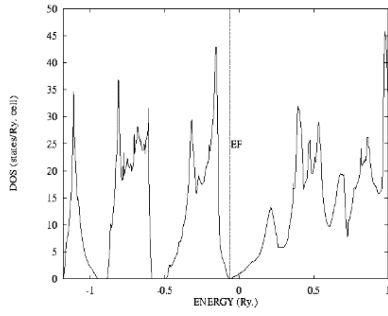


Fig.11: DOS of RbI at Metallization Fig.12: DOS of CsI at Metallization

3.Results and Discussion

3.1 Ground State and its Properties

The ground state properties of NaI, RbI and CsI are studied using the total energies obtained in our calculation. The total energy is calculated as a function of reduced volume. Here V_0 is the experimental equilibrium volume corresponding to the experimental equilibrium lattice constant 12.212 a.u for NaI, $a_0 = 13.8790$ a.u. for RbI and 8.6327 a.u for CsI [4]. The calculated total energies were fitted to Murnaghan's equation of states,

$$P = 1.5 B_0 \left[\left(\frac{V_0}{V} \right)^{7/3} - \left(\frac{V_0}{V} \right)^{5/3} \right] [1 + 0.75 (B_0' - 4) \left(\frac{V_0}{V} \right)^{2/3} - 1] \text{ (Mbar)}$$

The graph plotting pressure vs various reduced volumes are given in Fig.14 for CsI. The equilibrium lattice constant (a_0), band gap (E_g), bulk modulus (B_0) and its pressure derivative (B_0') values for NaI, RbI and CsI are tabulated in Table 2. The graph plotting lattice constant vs various reduced volumes are given in Fig.13 for CsI. The graph shows that increase in reduced volume also increases lattice constant. The Reduced volume, Lattice constant, Pressure and Energy gap values of NaI, RbI and CsI are tabulated in Table 1. In certain pressure band gap becomes zero. This denotes metallization in CsI (Fig.15). Lattice constant is calculated using formula,

$$a = a_0 (V_0/V)^{1/3}$$

The energy gap is calculated using the formula,

$$E_g(P) = E_g(0) - (k \cdot P)$$

Similarly, these graphs can be plotted for RbI and NaI.

V/V_0	Pressure (Mbar)	E_g (eV)	Lattice Constant (a.u)
1	0	5.807	13.879
0.9	0.0143	5.8004	13.4

0.8	0.0417	5.7878	12.88
0.7	0.0959	5.7613	12.32
0.6	0.2084	5.7113	11.706
0.5	0.457	5.5967	11.016
0.4	1.103	5.2996	10.226
0.3	3.148	4.3589	9.29
0.2004	12.62	0.001	8.126

Table.1. Reduced volume, Pressure, Band gap and Lattice constant values of NaI, RbI, CsI

Ground State Properties	NaI	RbI	CsI
a₀, a.u.	12.212	13.879	8.6327
B₀	0.151	0.103	0.1140
B₀'	5.59	5.334	5.85
E_g	5.89	5.807	4.00

Table.2. Ground state properties

3.2 Metallization

At normal pressure, alkali halides are wide gap insulators. As pressure is increased, there is a charge transfer from s, p to d state, this causes the increase in the width of the valence band and also the empty conduction bands. These changes lead to the narrowing of the band gap and at particular pressure, there is a closing of band gap [2].

In NaI, metallization takes place by the indirect closure (Fig. 7) of band gap between valence band maximum at Γ point and conduction band minimum at the H point. The metallization volume of NaI is $V/V_0=0.2282$ which corresponds to the pressure $P_M=13.3726$ Mbar. The metallization occurs because of the closure of band gap between I-5p- like valence band and Na-3s- like conduction band (Fig.7).

In RbI, the direct closure of the band gap (Fig.8) takes place at the reduced volume of $V/V_0 = 0.2004$, the corresponding metallization pressure is $P_M = 12.62$ Mbar. The metallization occurs because of the closure of the band gap between the I-5p-like valence band and the Rb-4d-like conduction band (Fig.8).

In CsI the metallization occurs because of the closure of the band gap between I-5p-like valence band and Cs-5d-like conduction band. In this case, metallization occurs via closing of the direct band gap at Γ - point. The metallization pressure of 8.5106 Mbar is obtained corresponding to a volume of $(V/V_0)_M = 0.247$.

In all the cases above, there is a s, p to d transition of electrons leading to an increase in d-electron numbers. Thus, this increase in the d-electron number leads to a metallization in alkali iodides. The increase of pressure causes the broadening of bands which results in the decrease of density of states value in most of the energy regions of DOS histograms. Thus, the heights of the spikes are considerably reduced. In the DOS histograms, we can clearly see that there is appreciable value of $N(E_F)$ at $(V/V_0)_M$ which indicates the metallization [5].

Alkali Iodides	Metallization	
	P_M (Mbar)	$(V/V_0)_M$
NaI	13.3726	0.2282
RbI	12.62	0.2004
CsI	8.5106	0.247

Table. 3: Metallization Pressure and the corresponding reduced volume

Conclusion

The electronic band structure, density of states and metallization of the alkali iodides NaI, RbI, CsI are investigated. This compound becomes metal under high pressure. When the pressure is increased there is enhanced overlapping between the wave functions of the neighbouring atoms. As a result, the widths of the valence and empty conduction bands increase. These changes lead to the narrowing and closing of band gaps (Metallization). The metallization pressures of NaI, RbI, CsI are 13.3726 Mbar, 12.62 Mbar, 8.5106 Mbar and the corresponding metallization reduced volumes are 0.22, 0.2004, 0.247 respectively.

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Synthesis and Characterization of Tin Oxide (SnO₂) Nanoparticles

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ABSTRACT

The present study illustrates the characteristics and coprecipitation method for synthesis of Tin oxide nanoparticles. The tin oxide nanoparticles were produced by tin chloride and Cadmium as a dopant. Structure, size and surface morphology of the tin oxide was studied by X-ray diffraction (XRD), UV Spectroscopy, Morphological studies, EDAX. The crystalline size can be determined by Scherrer's formula is about 41.26 nm.

Keywords: Coprecipitation method, Morphological, FESEM.

1. Introduction

Nanostructured metal oxides and semiconductor materials have attracted much attention owing to their good mechanical magnetically, optical, electrical and physical properties. Among these Nanostructured metal oxides, stannous oxide (SnO₂) is an important p-type semiconductor material, with wide a wide band gap of $E_g=2.7\&3.2\text{eV}$. Tin belongs to Block P, Period 5 and oxygen belongs to the Block P, Period 2 in the periodic table [1]. Tin (IV) oxide, also known as stannic oxide, is the inorganic compound with the formula SnO₂. The mineral form of SnO₂ is called cassiterite, and this is the main ore of tin. Tin (IV) oxide crystallises with the rutile structure. As such the tin atoms are six coordinate and the oxygen atoms three coordinate [2]. Tin oxide is a versatile metal oxide because of its two characteristics; variable valence state and existence of oxygen vacancy defect.

Therefore, tin oxide has potentially wide application in catalysis, electrocatalysis, solar energy conversion, antistatic coatings, transparent conductive electrodes, and electrochromic devices [3]. Hydrous forms of SnO₂ have been described as stannic acid. Such materials appear to be hydrated particles of SnO₂ where the composition reflects the particle size. Tin (IV) oxide occurs naturally. Synthetictin (IV) oxide is produced by burning tin metal in air. Annual production is in the range of 10 kilotons [4]. Nanostructured materials have attracted great interest in both fundamental as well as applied research areas due to their outstanding physical and chemical properties and also promising applications in nanodevices [5].

2. Experimental setup

1M Tin chloride was dissolved in 50ml distilled water and stirred for half an hour thoroughly using stirrer. Similar way 0.01 CTAB was dissolved in 50ml of distilled water and stirrer half an hour. On the other hand, 2M NaOH was dissolved in 50ml distilled water stirrer half an hour and heat the solution up to 70°C. Then add the CTAB solution dropwise in tin chloride solution. Now add the above solution drop wise in NaOH solution. Precipitate was washed 5 times to remove impurity and washed 1 time with ethanol to remove unwanted residues. The solution was heated for 100°C in hot air oven until the water evaporates. The dried sample calcinated at 600°C in muffle furnace. Then the dried sample is finely powdered using agate motor.

3. Results and discussion:

3.1. Powder X-Ray Diffraction (PXRD)

Powder X-Ray Diffraction (PXRD) is usually performed for confirming the nature of the particles that are developed. The structural analysis was carried out by recording the powder X-ray diffraction (PXRD) spectrum at room temperature using X-ray diffractometer recorded in the 2θ range of 10 to 70 using Cu-Kα radiation ($\lambda=1.54060 \text{ \AA}$). The average grain size of SnO₂ nanoparticles can be calculated using Debye Scherrer's formula.

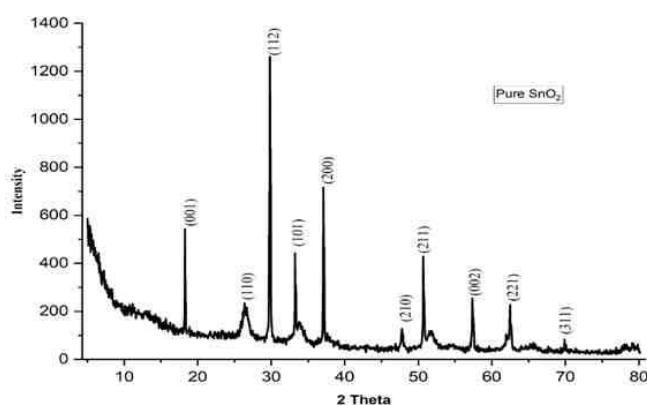


Fig.1 XRD Pattern of Pure SnO₂ Nanoparticles

The XRD patterns of pure SnO₂ nanoparticles. The Bragg reflections at scattering angles (2theta) of 26.330, 29.830, 33.270, 37.110, 51.780, 57.340, 62.460 and 69.920 corresponds to (110), (101), (200), (211), (002), (221) and (311) crystal plane respectively. All the diffraction peaks of pure SnO₂ match well with the tetragonal wurtzite structure of hexagonal phase with the JCPDS Card No:41-1445 and the lattice constants $a=4.738 \text{ \AA}$, $c=3.187 \text{ \AA}$ and cell volume $V=71.55(\text{\AA})^3$. The particle size for the pure SnO₂ nanoparticle is approximately 41.26 nm.

3.2 UV Spectroscopy

The excitation absorbance of pure SnO_2 is about 270nm. The optical bandgap E_g of the nanocrystals is calculated from the Tauc plot. The bandgap value of SnO_2 nanoparticles is found to be 2.8eV. The bandgap energy of the samples is measured by the extrapolation of the linear portion of the graph between the modified kubelka-Munk function $[F(R) \text{ hv}]^2$ versus photon energy (hv). The bandgap estimated for this sample (2.8eV) is slightly lower than that of bulk SnO_2 .

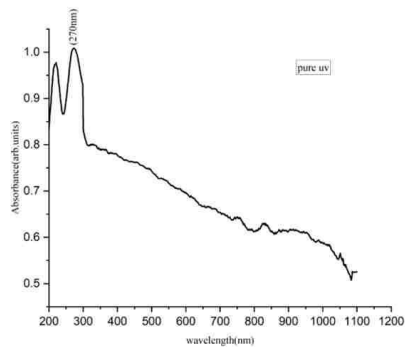


Fig.2 Absorption spectra of SnO_2 nanoparticles

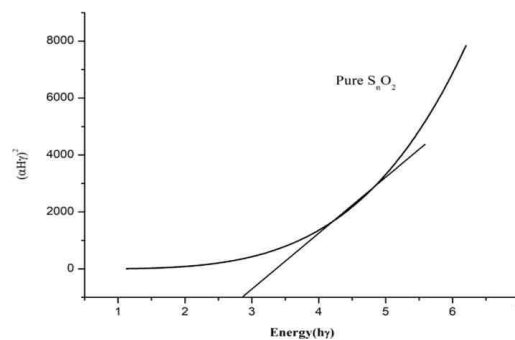


Fig.3 Tauc plot for SnO_2 nanoparticles

3.3. FESEM

Morphology of pure SnO_2 nanosheets

Typical FESEM Images of the SnO_2 nanostructures at four different magnifications are shown fig. It is clear that for 2 μm magnification, the synthesized SnO_2 nanoparticles are sheet like clusters which are formed in a large-scale area, highly dispersed in the space without any aggregation and have approximately uniform morphologies.

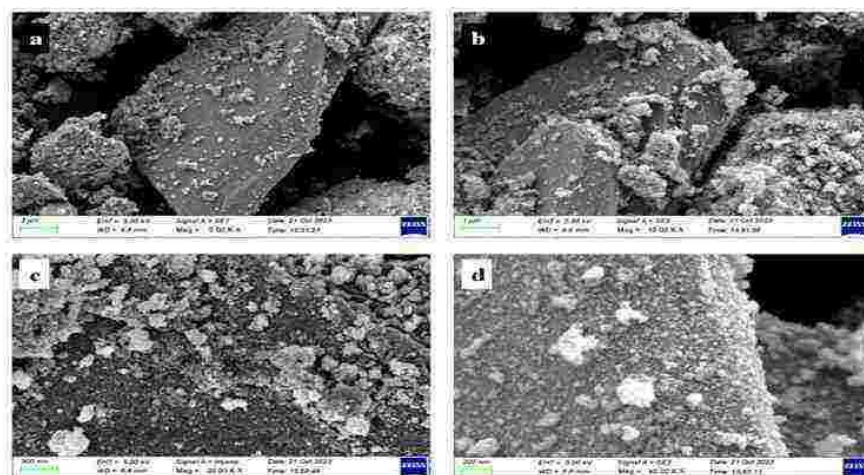


Fig.4 FESEM images of pure SnO_2 nanoparticles with magnification

a) 2 μm

b) 1 μm

c) 200 nm

d) 100 nm

3.4 EDAX spectra analysis of the SnO₂ nanoparticles

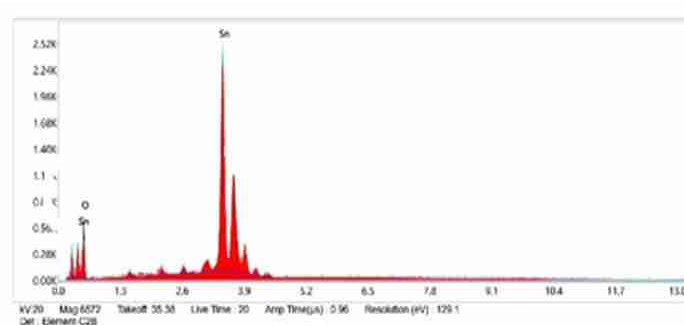


Fig.5 EDAX Spectra of Pure SnO₂ nanoparticles

Figure shows energy - dispersive x-ray spectroscopy (EDAX) of SnO₂ nanoparticles. The EDAX spectrum represents the chemical composition of elements present in prepared sample. The results demonstrate that Sn and O appear in SnO₂ sample. It is evident that the sample contains Cd, Sn, and O which confirms the purity of the sample without impurity traces.

Conclusion

Tin oxide nanoparticles were prepared by Co-precipitation method. The structural studies based on the X-ray diffraction and revealed that the synthesized nanomaterials are pure SnO₂ with a Tetragonal phase. The morphological properties of the SnO₂ were investigated by FESEM.

The PXRD suggested the crystalline sizes of SnO₂ nanoparticles are in the nano scale range. PXRD spectrum shows tetragonal structure of SnO₂ nanoparticles. The average grain size for heated pure SnO₂ at 600⁰C was found to be around 51.34 nm. The optical band gap is determined from the Tauc plot for pure 2.8eV. The surface morphology of the SnO₂ nanoparticle is characterized by FESEM analysis and suggested different structures. EDAX spectrum confirms the presence of elements Sn and O in pure SnO₂ nanoparticles.

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Hydrothermal Assisted Synthesis of CuO-Mn₂O₃ and CuO- Fe₂O₃ Nanocomposites: Structural and Optical Characterization

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ABSTRACT

CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites were prepared by hydrothermal method. The PXRD studies of CuO-Mn₂O₃ nanocomposites revealed that both CuO and Mn₂O₃ possessed monoclinic structure. The CuO nanocomposites showed strong absorption peaks in the UV region. The PL spectra exhibited blue and green emission band. The PL emission peaks were due to transitions originating from the recombination of shallowly trapped electron-hole pairs and/or excitons. The UV-Vis spectra of CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites showed absorption peaks at 290 nm and 285 nm which can be attributed to the LMCT (ligand-to-metal charge-transfer) transitions (direct transitions) with combined contributions from the Fe³⁺ ligand field transitions related to the morphology of the as-synthesized nanocomposites.

Keywords: Hydrothermal, Monoclinic, Photoluminescence, UV-Vis absorbance

1. Introduction

The development of a specific class of nanomaterials is crucial for the advancement of various unique functional and smart materials. Nanocomposites are materials composed of a matrix and nanoscale filler materials. The addition of nanoscale fillers such as nanoparticles or nanotubes can enhance the mechanical, thermal and electrical properties of the composite material [1-3]. CuO based nanocomposites exhibit exceptional chemical and physical properties that are very different from those of their micro or bulk counterparts. The attractive physical and chemical properties in transition metal oxide (TMO) nanomaterials can be attributed to their high specific surface area, higher surface energy and quantum confinement. These nanostructures have found application in various industrial scenarios, showcasing their versatile capabilities [4-5]. They may also have size effects and a high surface-to-volume ratio [6]. CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites are the ideal building blocks for composite assemblies with a range of components to increase their various biological and photocatalytic uses due to their attractive structural properties. Consequently, the most popular technique for producing effective nanocomposites is the binary design, which involves combining inorganic nanostructures with CuO nanoparticles [7].

2. Experiments and Methods

In this study hydrothermal assisted co-precipitation method is used to prepare CuO nanoparticles and composites of copper oxide namely CuO-Mn₂O₃, CuO-Fe₂O₃ nanocomposites. The high quality analytical graded material used for preparing the nanomaterials consist of copper sulphate, manganese oxide, ferric chloride, double distilled water and sodium hydroxide.

2.1 Experimental method to synthesize CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites

Initially, copper sulphate and manganese oxide precursors for preparing CuO-Mn₂O₃ nanocomposites and copper sulphate with Ferric chloride for preparing CuO-Fe₂O₃ nanocomposites were dissolved completely in double distilled water (100mL) at room temperature. Under continuous stirring, the as-prepared NaOH solution (1.6 M) was added drop by drop to the above solutions. Then, the mixture was transferred to a Teflon-lined stainless-steel autoclave and kept under hydrothermal conditions (150 °C, 16 hours). After the completion of the reaction time, the dark brown and black slurry was brought to ambient temperature. The precipitates were washed 5 times using double distilled water and finally 2 times using ethanol and double distilled water and dried at 100 °C. The products were finally calcined at 500°C for 2 hours. The obtained CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites samples were black and brown in colours respectively.

3. Results and Discussion

3.1 PXRD Analysis

The structural characterization of copper oxide-based nanocomposites was carried out by recording the powder X-ray diffraction (PXRD) spectrum using X-ray diffractometer with Cu-K_α as the radiation source (wavelength: 1.54056 Å) over the 2θ range of 10° to 80°. The average grain size is calculated using the Scherrer formula

$$D = 0.9 \lambda / \beta \cos \theta$$

where λ is the wavelength of the Cu-K_α radiation [1.54060 Å], β is the full width half maximum of the diffraction line and θ is the angle of diffraction. Fig.1 shows the PXRD pattern of the synthesized CuO/ Mn₂O₃ nanocomposites. The peaks of Mn₂O₃ are observed at (310), (202), (112), (221) and (511) corresponding to $2\theta = 31.70^\circ$, $2\theta = 37.38^\circ$ and $2\theta = 40.74^\circ$, $2\theta = 57.36^\circ$ and $2\theta = 59.53^\circ$ respectively and the peaks of CuO are observed at (111), (020), (022) and (310) corresponding to $2\theta = 35.61^\circ$, $2\theta = 52.19^\circ$, $2\theta = 56.14^\circ$, $2\theta = 64.80^\circ$ and $2\theta = 66.62^\circ$ respectively. The Mn₂O₃ peak corresponding to (202) is of high relative intensity. The average grain size D is 42nm. The PXRD peaks of CuO-Mn₂O₃ nanocomposites perfectly matched with that of the JCPDS File No. 89-7047 and JCPDS File

No.39-1218. From this data, the PXRD studies of CuO-Mn₂O₃ nanocomposites revealed that CuO and Mn₂O₃ possessed monoclinic structure.

Fig.2 shows the PXRD pattern of the CuO-Fe₂O₃ nanocomposites. The peaks of Fe₂O₃ are observed at (013), (131), (123), (114) and (234) corresponding to $2\theta = 30.48^\circ$, $2\theta = 36.04^\circ$, $2\theta = 39.26^\circ$, $2\theta = 43.70^\circ$, $2\theta = 62.44^\circ$, respectively. The peaks of CuO are observed at (202), (202) and (311) corresponding to $2\theta = 48.97^\circ$, $2\theta = 58.07^\circ$, and $2\theta = 66.57^\circ$ respectively. The Fe₂O₃ peak corresponding to (131) is of high relative intensity. The average grain size D is 20 nm. The PXRD peaks of CuO-Fe₂O₃ nanocomposites perfectly matched with that of the JCPDS File No. 89 - 2530 and JCPDS File No. 89 - 7047. From this data, the PXRD studies of CuO-Fe₂O₃ nanocomposites revealed that CuO and Fe₂O₃ possessed monoclinic and orthorhombic structures respectively.

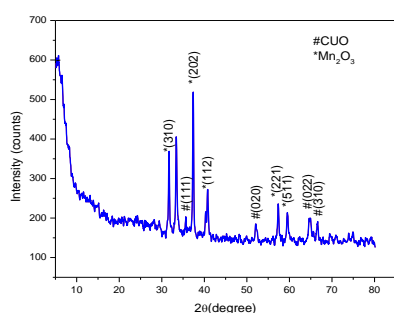


Fig.1 PXRD pattern of CuO - Mn₂O₃ nanocomposites

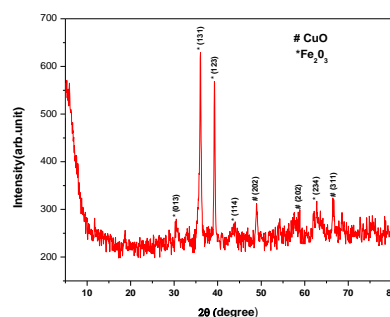


Fig.2 PXRD pattern of CuO - Fe₂O₃ nanocomposites

3.2 Photoluminescence (PL) Spectroscopy

Fig.3 shows the PL emission spectra of CuO-Mn₂O₃ with almost prominent peak at 360 nm and smaller peaks at observed at 375 nm, 410 nm, 436 nm, 460 nm, 494 nm, 505 nm, 521 nm, 536 nm, 546 nm, 573 nm and 584 nm. Fig.4 shows the PL emission spectra of CuO/Fe₂O₃ exhibiting the most prominent peak at 360 nm and smaller peaks are observed at 377 nm, 410 nm, 438 nm, 461 nm, 494 nm, 505 nm, 522 nm, 537 nm, and 573 nm due to the presence of singly ionized oxygen vacancies [8]. The photoluminescence spectrum revealed blue and green emission bands in both nanocomposites.

3.3 UV-Vis Spectroscopy

The optical absorbance spectra of CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites are shown in Fig.5 and Fig.6 respectively. The absorbance spectra of CuO-Mn₂O₃ nanocomposites exhibited a maximum peak at 290 nm with absorbance 0.65 (arbitrary units). The absorbance spectra of CuO-Fe₂O₃ nanocomposites exhibited a maximum peak at 285 nm with absorbance 1.0 (arbitrary units) which can be attributed to the LMCT (ligand-to-metal

charge-transfer) transitions (direct transitions) with combined contributions from the Fe^{3+} ligand field transitions ${}^6\text{A}_1({}^6\text{S})$ to ${}^4\text{T}_1({}^4\text{P})$ at 290 nm - 310 nm. Such absorption is related to the morphology of the nanomaterials [9]. The UV peaks in the blue region in both the $\text{CuO-Mn}_2\text{O}_3$ and $\text{CuO-Fe}_2\text{O}_3$ nanocomposites confirm the nanosize of the as-synthesized nanocomposites.

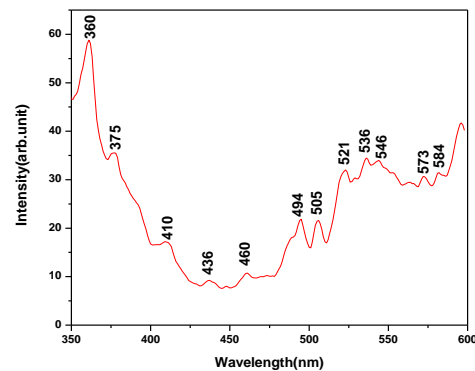


Fig.3 PL emission spectra of $\text{CuO-Mn}_2\text{O}_3$ nanocomposites

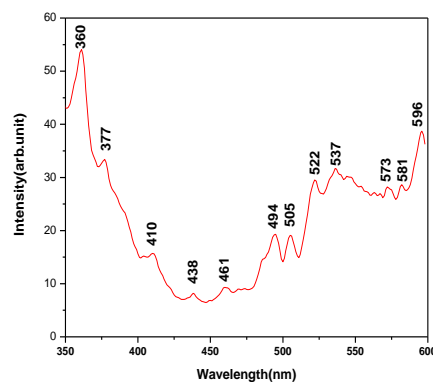


Fig.4 PL emission spectra of $\text{CuO-Fe}_2\text{O}_3$ nanocomposites

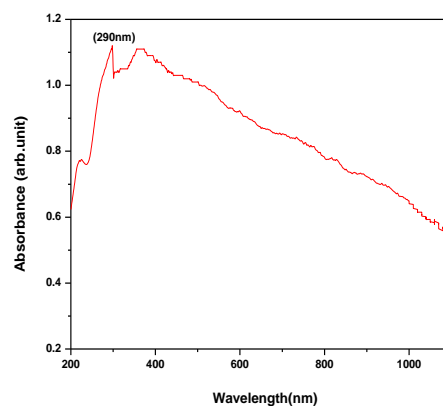


Fig.5 Absorbance spectra of $\text{CuO-Mn}_2\text{O}_3$ nanocomposites

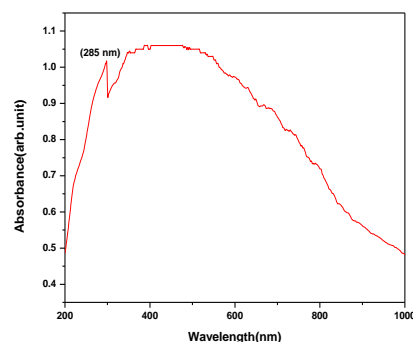


Fig.6 Absorbance spectra of CuO-Fe₂O₃ nanocomposites

Conclusion

In this present work, the CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites were prepared by hydrothermal method. The PXRD studies of CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites revealed that CuO possessed monoclinic structure and Mn₂O₃-Fe₂O₃ possessed monoclinic and orthorhombic structure respectively. The PL spectra exhibited blue and green emission band. The CuO nanocomposites have strong absorption peaks in the UV region which can be attributed to the LMCT (ligand-to-metal charge-transfer) transitions (direct transitions) with combined contributions from the Fe³⁺ ligand field transitions. The CuO-Mn₂O₃ and CuO-Fe₂O₃ nanocomposites have been successfully used to shift the material's bandgap and can be used for optoelectronic applications.

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Structural and Optical Properties of ZnO-Mn₂O₃ and ZnO-MgO Nanocomposites synthesized by Co-precipitation method

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ABSTRACT

In the present work, co-precipitation method was used to generate the ZnO-Mn₂O₃ and ZnO-MgO nanocomposites. The structure of the ZnO-Mn₂O₃ and ZnO-MgO nanocomposites was revealed by PXRD. It is confirmed that the synthesized pure ZnO and Mn₂O₃ exhibited cubic and hexagonal structure respectively in ZnO-Mn₂O₃ nanocomposites. The synthesized ZnO-MgO nanocomposites exhibited cubic structure. According to the PL technique, the visible region's blue and green shift emission was represented by the peaks that form between 360 and 573 nm. The optical characteristics of the composites were investigated using UV-Vis-Spectroscopy. The broad absorption band that ranges towards longer wavelength might be owing to the movement of the electronic cloud on the overall skeleton of the ZnO based nanocomposites. The produced ZnO-Mn₂O₃ and ZnO-MgO nanocomposites were appropriate materials for photocatalysis in environment remediation applications.

Keywords: Nanocomposites, Metal oxide, PXRD, Absorption, Emission

1. Introduction

Nanocomposite is a multiphase solid material where one of the phases has one, two or three dimensions of less than 100 nanometers (nm). They are materials that are heterogenous or hybrid synthesized by incorporating nanosized particles obtained from standard material with unique property combinations [1]. Zinc oxide (ZnO) based nanomaterials have been extensively applied in several areas, such as adsorption, photocatalysis, food preservation/antibacterial, photoluminescence, photoelectrocatalytic, and pollutant sensors. This is due to their prominent electronic, thermal, and optical properties along with their biocompatibility and reusability. ZnO catalyst is characterized by its high-binding exciting energy (60 mV) and large-scale band gap (3.00–3.37 eV) [2 - 4]. ZnO nanoparticles are used as an active ingredient in paints, lotions, ointments, and mouthwashes. They are flexible semiconductor photoconductive substances [5, 6].

2. Materials and Methods

Co-precipitation method is used to prepare ZnO-Mn₂O₃ and ZnO-MgO

nanocomposites. The materials used for preparing the nanomaterials consist of analytical graded zinc acetate, manganese acetate, magnesium acetate, double distilled water and sodium hydroxide. For the synthesis of ZnO-Mn₂O₃ nanocomposites, zinc acetate (2.195 g) is dissolved in 100 ml distilled water and manganese acetate (2.450 g) is dissolved in 100 ml distilled water using a magnetic stirrer for 30 minutes. The resulting solutions are mixed together with a magnetic stirrer for an additional 30 minutes. Subsequently, 6.4 g of sodium hydroxide dissolved in 50 ml distilled water is added drop by drop to the mixture to maintain a pH value of 10. The precipitate is washed five times with double-distilled water and finally twice with ethanol. The sample is then dried in an oven at 100°C for 8 hours, powdered and subjected to a calcination process in a muffle furnace at 400°C and 500°C for 2 hours, resulting in the ZnO-Mn₂O₃ nanocomposite in black powdery form. Similar method is chosen for the synthesis of ZnO-MgO nanocomposites,

3. Results and Discussion

3.1 PXRD analysis

The structural characterization of the ZnO-Mn₂O₃ and ZnO-MgO nanocomposites was investigated by recording the powder X-ray diffraction (PXRD) spectra using X-ray diffractometer. The average grain size can be quantitatively found out using the Scherrer formula where λ is the wavelength of the Cu- α radiation [1.54060 Å], β is the full width half maximum of the diffraction line and θ is the angle of diffraction [6]. Fig.1 depicts the PXRD pattern of the produced ZnO-Mn₂O₃ nanocomposites. The peaks of Mn₂O₃ are observed at (122), (222), (433), (061) and (262) corresponding to $2\theta=29.97^\circ$, $2\theta=32.16^\circ$, $2\theta=57.13^\circ$, $2\theta=59.63^\circ$, $2\theta=65.17^\circ$ respectively and the peaks of ZnO are observed at (100), (111) and (220) corresponding to $2\theta=31.43^\circ$, $2\theta=36.62^\circ$ and $2\theta=61.80^\circ$ respectively [ZnO (JCPDS File No: 36 - 1451) and Mn₂O₃ (JCPDS File No: 89 - 4836)]. The Mn₂O₃ peak associated with (111) has a high relative intensity. Using the Scherrer equation, the average grain size D is estimated to be 23 nm. It is confirmed that the synthesized pure ZnO and Mn₂O₃ nanoparticles exhibit cubic and hexagonal structure respectively. The PXRD pattern of the produced ZnO-MgO nanocomposites is shown in Fig.2. MgO peaks are observed at (200), (111), (111), and (220), corresponding to $2\theta=19.03^\circ$, $2\theta=32.08^\circ$, $2\theta=34.74^\circ$, $2\theta=38.27^\circ$, $2\theta=63.13^\circ$, and $2\theta=58.77^\circ$, respectively and ZnO peaks are observed at (002), (222), (102), (112), and (110) corresponding to $2\theta=36.56^\circ$, $2\theta=47.54^\circ$, $2\theta=56.60^\circ$ and $2\theta=58.74^\circ$ respectively [ZnO (JCPDS FileNo: 89 - 0510) and MgO (JCPDS FileNo: 76 - 1363)].

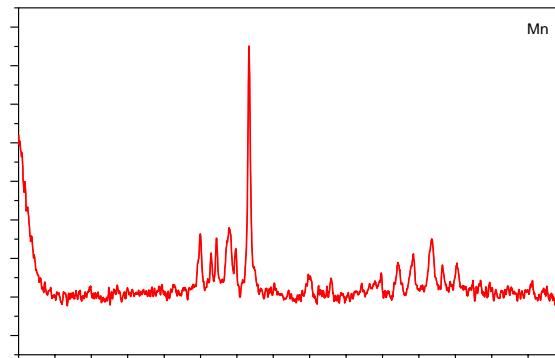


Fig.1 PXRD pattern of ZnO-Mn₂O₃ nanocomposites

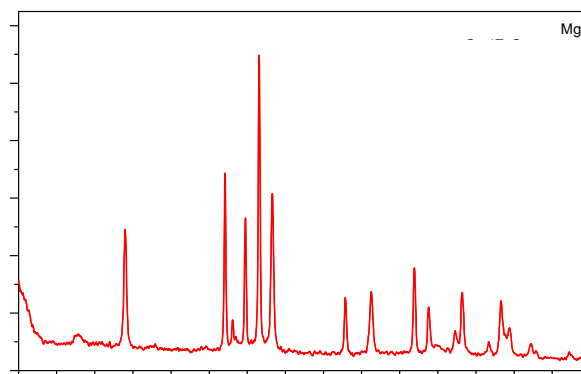


Fig.2 PXRD pattern of ZnO-MgO nanocomposites

The MgO peak associated with (111) has a high relative intensity. The synthesized ZnO-MgO nanocomposites exhibited cubic structure and the average grain size D is calculated as 29 nm.

3.2 Photoluminescence (PL) analysis

Photoluminescence (PL) studies for the synthesized ZnO-Mn₂O₃ and ZnO-MgO nanocomposites were carried out using a photoluminescence spectrophotometer and the emission spectra were recorded at a scan rate of 600 nm/min using the excitation wavelength of 320 nm. The PL emission spectra of ZnO-Mn₂O₃ nanocomposites are shown in Fig.3 showing a maximum peak at 361nm, and other peaks at 377 nm, 409 nm, 437 nm, 460 nm, 494 nm, 505 nm, 536 nm and 573 nm, each corresponding to a specific energy level occurring due to the presence of singly ionized oxygen vacancies [7]. Fig.4 depicts the photoluminescence (PL) emission spectra of ZnO-MgO nanocomposites, where distinct peaks emerged at 360 nm, 388 nm, 410 nm, 437 nm, 460 nm, 493 nm, 506 nm, 521 nm and 572 nm, each corresponding to a specific energy level. The PL emission peaks in the blue and green region in both the ZnO-MgO and ZnO-Mn₂O₃ nanocomposites showed the nanosize of the as-synthesized nanocomposites [8, 9].

3.3 UV-Visible analysis

The absorbance spectra of the produced ZnO-Mn₂O₃ nanocomposites are given in Fig.5 with a maximum peak at 236 nm. The absorbance spectra of the produced ZnO-MgO nanocomposites are depicted in Fig.6 with a maximum peak at 299 nm. The broad absorption band that ranges towards longer wavelength might be owing to the movement of the electronic cloud on the overall skeleton of the ZnO based nanocomposites [10].

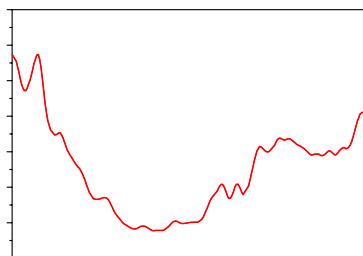


Fig.3 PL emission spectra of ZnO-Mn₂O₃ nanocomposites

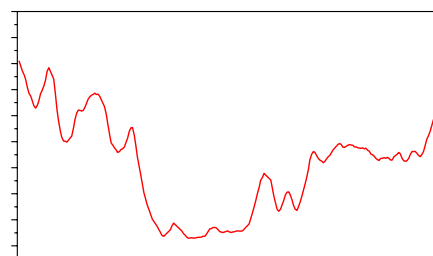


Fig. 4 PL emission spectra of ZnO-MgO nanocomposites

Conclusion

The development of advanced materials with modified heterojunctions is the current necessity for environmental protection and nanomedicine applications. Co-precipitation method is used to create ZnO-Mn₂O₃ and ZnO-MgO nanocomposites. Using the PXRD pattern analysis, the average approximate grain sizes of ZnO-Mn₂O₃ and ZnO-MgO nanocomposites are found to be 23 and 29 nm respectively. In the PL emission spectra, peaks develop between 361 nm and 360 nm, representing blue and green shift emission in the visible region. The optical absorbance properties of ZnO-Mn₂O₃ and ZnO-MgO nanocomposites show high absorption peaks in the UV range for waste water treatment applications.

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CdO-MgO and CdO-Fe₂O₃ Nanocomposites: Ultrasonication Assisted Synthesis and Characterization

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ABSTRACT

Binary CdO-MgO and CdO-Fe₂O₃ nanocomposites were synthesized using a cost-effective co-precipitation method. For CdO-MgO, cubic CdO and rhombohedral MgO structures were observed, while CdO-Fe₂O₃ exhibited cubic CdO and rhombohedral Fe₂O₃ structures. The absence of impurity peaks confirmed the formation of pure CdO-based nanocomposites. Photoluminescence analysis revealed blue and green shift emissions (340–560 nm), and UV-Visible spectroscopy showed strong absorption peaks in the UV region, effectively modifying bandgap values through electronic transitions. Thus, CdO based nanocomposites, recognized for their electronic and magnetic properties, hold promise for electrocatalysis and photocatalytic applications.

Keywords: Nanocomposites, CdO-MgO, CdO-Fe₂O₃, Co-precipitation method, Nanoparticles

1. Introduction

In recent years, significant attention has been drawn to metal oxide nanocomposites due to their distinctive structural, electrical, mechanical, photocatalytic, adsorbent, thermal, and optical characteristics [1, 2]. Photovoltaic equipment, UV sensors, gas detectors, batteries and solar cells are just a few of the many fields where nanocomposites show great potential [3 - 6]. Cadmium oxide (CdO) is an n-type semiconductor with a band gap of 2.5 eV. It has attracted a lot of attention due to its possible uses in solar cells and photodiodes, among other domains [7, 8]. The combination of different metal oxides to form nanocomposites has resulted in significant improvements in the properties of each individual oxide. This advancement has opened up new avenues for groundbreaking research in areas such as photocatalysis, optoelectronics, electrical applications, and biological applications [9].

2. Experimental Procedure

The co-precipitation method is employed to synthesize CdO-MgO and CdO-Fe₂O₃ nanocomposites. Analytical-grade chemicals, including Cadmium nitrate, Iron (III) nitrate, Magnesium nitrate, double distilled water and Sodium hydroxide are utilized. In a typical

synthesis, 0.1 M of each precursor salt with a mole ratio of 1:1:1 (Mg: Cd: Fe) was dissolved in 100 ml of distilled water and magnetically stirred for 1 hour at room temperature. 1.6 M NaOH solution was added drop-wise to the precursor solution with vigorous stirring until reaching a pH of 10. The precipitates were formed instantaneously and subjected to ultrasonication for 30 minutes (Powersonic 405). Then, the obtained precipitate was thoroughly washed with double-distilled water followed by ethanol. The prepared sample was dried in a hot air oven at 100°C. The sample was then calcined at two different temperatures, 400°C and 500°C, for 2 hours.

Characterization: PXRD analysis utilized CuK_α radiation ($\lambda=1.5406 \text{ \AA}$) within a 2θ range of 10° – 80° , operated at 40kV and 30mA. Photoluminescence studies employed a Cary Eclipse spectrophotometer, recording emission spectra were recorded at a scan rate of 600 nm/min with an excitation wavelength of 320 nm using He-Cd laser at room temperature. UV-Vis absorption spectra were obtained with a Hitachi U-2900 spectrophotometer in the 190 - 800 nm range after dispersing samples in absolute ethanol through ultrasonication.

3. Results and Discussion

3.1 PXRD analysis

The PXRD (Powder X-ray diffraction) patterns presented in Fig. 1 and Fig. 2 correspond to CdO-MgO and CdO-Fe₂O₃ nanocomposites, which underwent calcination at 400°C. The average grain size was calculated using Scherrer's formula [7].

$$D = \frac{0.9 \lambda}{\beta \cos \theta}$$

where, D is the average crystallite size, $K=0.9$ (is a constant), λ represents the wavelength of the CuK_α radiation (1.54060 \AA), β is the line broadening at full width half maximum of the diffraction line and θ is the angle of diffraction. In Fig.1, the PXRD pattern of CdO-MgO nanocomposites with an average grain size (D) of 36.13084 nm is illustrated, showing MgO peaks (JCPDS Card No.: 27-0759) at (202), (220), (312), (443) with 2θ values of 23.61° , 30.39° , 35.27° , 67.23° , and CdO peaks (JCPDS Card No.: 78-1125) at (111), (210), (220), (221), (311), (222), (023), (410) with 2θ values of 29.55° , 37.88° , 49.02° , 52.36° , 56.14° , 61.29° , 64.69° , 74.56° . The MgO (312) peak exhibits high relative intensity.

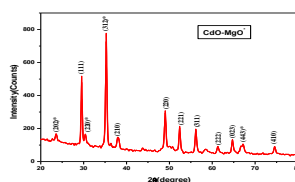


Fig.1 PXRD pattern of CdO-MgO nanocomposites

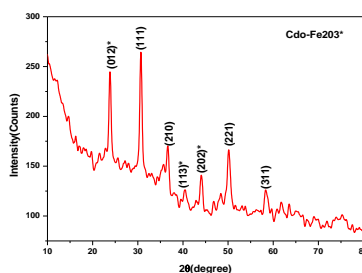


Fig.2 PXRD pattern of CdO-Fe₂O₃ nanocomposites

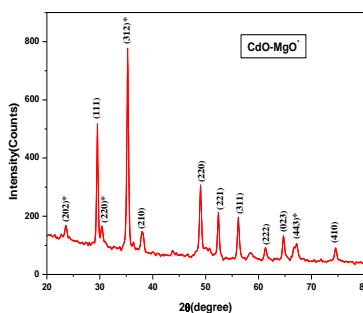


Fig.1 PXRD pattern of CdO-MgO nanocomposites

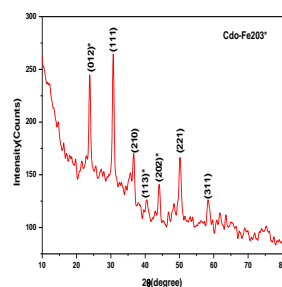


Fig.2 PXRD pattern of CdO-Fe₂O₃ nanocomposites

In Fig.2, the PXRD pattern of CdO-Fe₂O₃ nanocomposites with an average grain size (D) of 20.554389 nm is displayed, revealing Fe₂O₃ peaks (JCPDS File No. 89-0597) at (012), (113), and (202) with 2θ values of 23.82°, 40.42°, and 44.10°. CdO peaks (JCPDS Card No.: 78 - 1125) at (111), (210), (221), and (311) are observed at 2θ values of 30.75°, 36.55°, 50.02°, and 58.31°, with the (111) peak exhibiting high relative intensity [8].

3.2 Photoluminescence (PL) Spectroscopy

Fig.3 depicts PL emission spectra of CdO-Mg nanocomposites, revealing a prominent peak at 360 nm along with smaller peaks at 377 nm, 410 nm, 435 nm, 460 nm, 492 nm, 522 nm, and 573 nm. In Fig. 4, CdO-Fe₂O₃ nanocomposites show a maximum intensity peak at

360 nm accompanied by smaller peaks at 376 nm, 410 nm, 436 nm, 494 nm, 522 nm, and 573 nm. Notably, blue emission peaks are observed at 460 nm, 492 nm and 494 nm while the green emission peaks are at 522 nm. The photoluminescence spectrum illustrates the presence of blue and green emission bands in both nanocomposites.

3.3 UV-Vis Spectroscopy

Fig.5 displays the optical absorbance spectra of CdO-MgO nanocomposites, revealing an absorption peak at 230 nm with an absorbance of 0.55 (arbitrary units). In Fig. 6, the optical absorbance spectra of CdO-Fe₂O₃ nanocomposites show a maximum peak at 371 nm with an absorbance of 1.0 (arbitrary units). UV peaks in the blue region for both CdO-MgO and CdO-Fe₂O₃ nanocomposites confirm their nanosize [9].

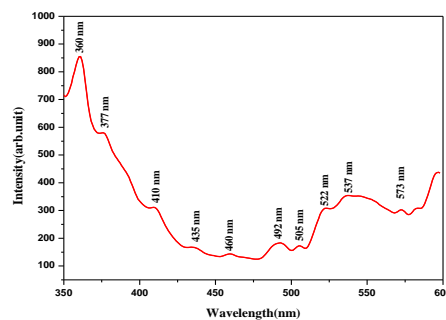


Fig.3 PL emission spectra of CdO-MgO nanocomposites

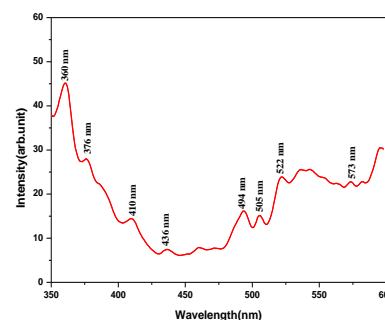


Fig.4 PL emission spectra of CdO-Fe₂O₃ nanocomposites

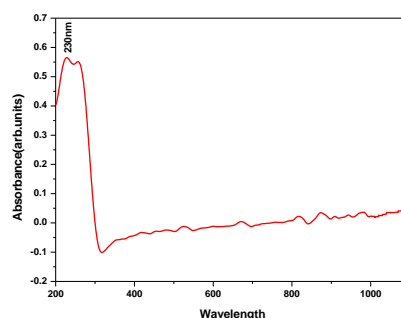


Fig.5 Optical absorbance spectra of CdO-MgO nanocomposites

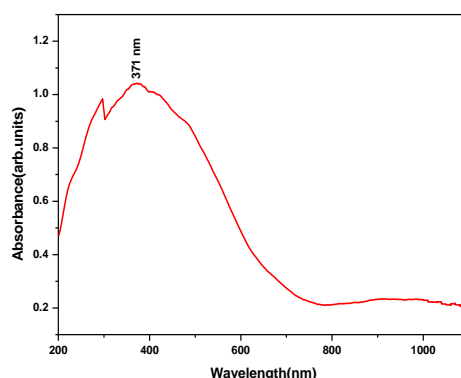


Fig.6 Optical absorbance spectra of CdO-Fe₂O₃ nanocomposites

Conclusion

CdO-MgO and CdO-Fe₂O₃ nanocomposites were synthesized using the co-precipitation method. The structural analysis by PXRD confirmed that CdO possessed cubic structure and MgO-Fe₂O₃ exhibited rhombohedral structure, devoid of impurities. Photoluminescence analysis revealed blue and green shift emissions (340 - 560 nm), and UV-Visible spectroscopy showed strong absorption peaks in the UV region, suitable for photocatalytic applications.

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Enhanced Properties of Orange Peel Imposed Epoxy Composite

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ABSTRACT

Over the last century, polymers have emerged as one of the most indispensable components used in everyday life, epoxy or poly-epoxide being one such example. Recently, synthetic filler materials have been the preferred choice for reinforcement of epoxy to improve its mechanical and tribological properties. However, natural fibers are emerging as suitable alternatives to synthetic materials for obvious reasons. In this work, pure epoxy sheet was initially formed by solution casting method and the orange peel powder (5wt%, 10wt%) imposed epoxy sheets were also developed. The FTIR of epoxy reveals the functional groups present in the sample. The dielectric constant increases with the increase in temperature for all the tested nanocomposites. The thermal stability of polymer composites was analyzed using the thermal analyzer and neat epoxy showed enhanced thermal properties when compared with orange peel powder-imposed epoxy composite.

Keywords: Orange peel, Epoxy, Electrical analysis, Thermal analysis

1. Polymers

Polymeric materials have excellent thermal, chemical and dielectric properties. Polymers are key enablers in electronic packaging. There are two basic classes of polymers; thermoplastics and thermosets [1]. Polymers are long chains of repeating chemical units. Polymers can be linear (polystyrene, polypropylene), branched (polyethylene) or cross-linked (epoxy). Thermoplastics are very long polymer chains with a high molecular weight and can be either crystalline or amorphous [2]. The high molecular weight of polymers imparts their useful properties such as good mechanical property and the ability to be moulded into various types (injection moulded, extruded, etc [3]. The main drawbacks of using thermoplastic polymers in electronic packaging are, as the molecular weight increases, the viscosity increases very rapidly requiring processing at temperatures above the melting point and In use, if the T_g or T_m is exceeded [4], the dimensional stability limits the use in electronic packaging, since most of the electronic packages experience multiple solder reflows where the temperature is likely to be in the range of 220°C - 260°C, well above the T_m or T_g of most thermoplastics [5]. Thermosets are a class of polymers that start out as small molecules (monomers and oligomers) and during a chemical reaction polymerize into a cross-linked

network structure [6]. In the final fully cured state, the crosslinks join the chains together providing good mechanical properties, but thermosets will not flow above the T_g [7]. The use of small molecules as starting materials allow for many types of processing such as adhesive dispense, moulding of epoxy mould compounds, application of protective coating layers, lamination of multilayer printed circuit substrates and more [8]. The cured epoxy resin system has good electric performance in wide frequency and temperature ranges. It is a good insulating material with high dielectric, surface leakage resistance and good arc resistance [9]. The combination of good processing characteristics and useful properties has led to the use of epoxy resins in many applications including adhesives, in electronics for encapsulation, potting and printed circuit boards, and in the aerospace industries as matrices for composites and tile material [10].

In this study, orange peel powder-imposed epoxy polymer nanocomposite was prepared to enhance their mechanical strength, thermal properties and dielectric properties.

2. Materials and Methods

2.1 Epoxy Resin

Epoxy resin LY556 chemically belongs to epoxide family. Its common name is BisPhinol-A-Diglycide-Ether. It is commonly used in the production of adhesives coatings and in the production of composite materials. This resin is commonly employed because of its high strength, and resistance to chemicals and moisture. LY 556 typically involves the use of a hardener for the initiation of the curing process. The type of hardener used is HY951, which has low viscosity, curing at room temperature and excellent electrical properties. It also has good mechanical strength, good resistance to atmosphere and chemical degradation.

2.2 Preparation of pure epoxy sheet

Epoxy resin of 60gm and hardener of 12gm were poured in a beaker and stirred for 3 minutes using a mechanical stirrer. Before the mixture was poured into the metal mould some Vaseline was applied for ease of removal of the sheet. Then the mixture was poured into the metal mould. The metal mould was left undisturbed for a day at room temperature. Finally, the sample was cured by keeping the mould in an oven at 100 degrees Celsius for 2 hours. After the curing process the mould was again kept at room temperature for cooling. When the mould attains the rooms temperature the synthesized sheet can be separated from the metal mould. Thus, neat epoxy sheet was obtained.

2.3 Preparation of Epoxy/ Orange peel Composite

The orange peel powder of 5wt% was dispersed into 60gm of epoxy resin and both were mixed by high speed in a mechanical stirrer for 3 hours, 12gm of hardener was slowly

into epoxy- composite and stirred using a mechanical stirrer for 3 mins. Before the mixture was poured into the metal mould some Vaseline for applied for easily removing the sheet. Then the mixture was poured into the metal mould. The metal mould was kept undisturbed for one day at room temperature. Then the sample was cured by the keeping in the hot air oven for 100degree Celsius for 2 hours. After curing process, the mould was kept at room temperature for cooling. When the mould attains the room temperature the developed sheet was removed from the metal mould.



Fig.1: Photograph of the pure and orange peel-imposed epoxy composites

3. Results and Discussion

3.1 Fourier Transform Infrared Spectroscopy

Fourier transform infra-red spectroscopy is used to characterize the functional groups of prepared pure epoxy and orange peel-imposed epoxy samples. The mode used in this FTIR characterization is transmission. FTIR measurements for the samples are performed in the range of $4000 - 400 \text{ cm}^{-1}$. The FTIR spectrum for all prepared samples is shown in figure 2.

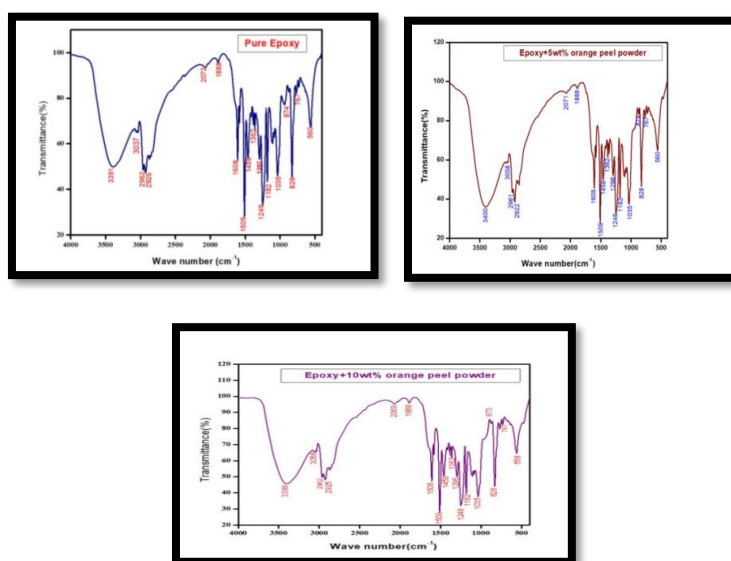


Fig.2: FTIR spectra of pure and orange peel-imposed epoxy composites

The structure of LY 556 epoxy resin and HY 951 hardener were confirmed by FTIR spectral analysis. In the FTIR spectrum of pure epoxy, the band at 3400 cm^{-1} corresponds to bonded O-H stretching. The peak at 3058 cm^{-1} indicates the stretching of C-H in aromatics. The band at 2962 cm^{-1} and 2926 cm^{-1} corresponds to the asymmetric C-H stretching of CH_2 and CH_3 groups. The band at 1608 cm^{-1} corresponds to the C=C stretching of aromatic rings. The band at 1509 cm^{-1} corresponds to the C-C stretching vibration in aromatic ring. The band at 1458 cm^{-1} corresponds to the C-C stretching vibration in aromatic ring. The band 1296 cm^{-1} corresponds to the asymmetric CH_2 deformation. The asymmetric aliphatic C-O stretching produces absorption bands at 1182 cm^{-1} . The asymmetric stretching mode of C-O-C vibration appears at 1035 cm^{-1} . The strong absorption peak at 828 cm^{-1} indicates C-H out of plane deformation in aromatic rings. The band at 767 cm^{-1} corresponds to the C=C bending. The sharpness and intensity only vary for different weight percentage orange peel added epoxy composite. A slight shift in absorption bands is observed for orange peel added epoxy systems.

3.2 Dielectric analysis

3.2.1 Dielectric constant

It is based on the phenomenon of electrical polarization and electrical conduction in materials. In the present work the relative permittivity and the loss tangents are determined.

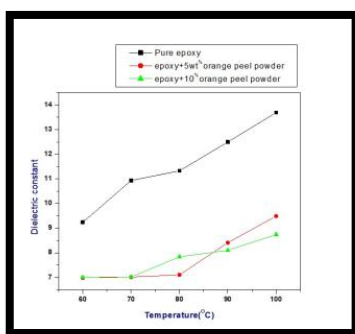


Fig.3: Dielectric constant Vs Temperature at 1KHz

It can be seen that the dielectric constant increases with the increase in temperature for all the tested composites. This dependence is observed for pure and all the two filler concentrations. At low temperatures the orientational mode cannot contribute to polarization. This leads to a lower dielectric constant at low temperatures. The dielectric constant of unfilled epoxy and orange peel-imposed epoxy composites increases with decreasing frequency.

Temperature (°C)	Pure Epoxy				Epoxy+5wt% orange Peel powder				Epoxy+10wt% orange peel powder			
	1 KHz	10 KHz	100 KHz	1 MHz	1 KHz	10 KHz	100 KHz	1 MHz	1 KHz	10 KHz	100 KHz	1 MHz
100	13.689	12.586	11.627	12.848	9.489	9.284	8.324	7.983	8.743	7.987	8.643	7.645
90	12.498	12.354	11.164	11.812	8.413	8.876	8.256	7.876	8.102	7.843	8.543	7.429
80	11.328	11.970	10.930	11.282	7.110	8.110	8.145	7.546	7.843	7.664	8.430	7.368
70	10.936	10.650	9.261	9.293	7.018	8.074	7.876	7.348	7.024	7.430	8.338	7.114
60	9.239	9.537	9.647	9.211	6.987	7.998	7.546	7.119	7.000	6.998	8.214	6.878

3.2.2 Dielectric Loss

Dielectric loss depends on the electrical conductivity which in turns depends on the number of charge carriers in the bulk of the material, the relaxation time of the charge carriers and the frequency of the applied electric field.

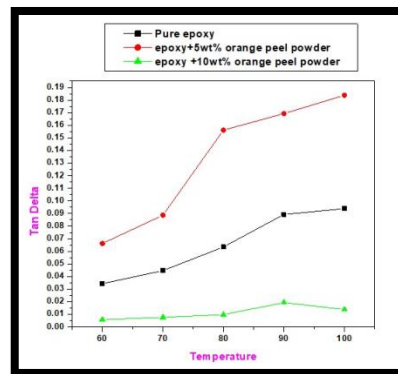


Fig.4: Dielectric loss Vs Temperature at 1KHz

It can be seen that dielectric loss increases with increase in temperature for all the tested samples. This dependence observed for pure and all imposed orange peel concentrations. The dielectric loss values for orange peel-imposed epoxy composite are less than that of unfilled epoxy. Dielectric loss depends on the electrical conductivity in turn depend on the number of charge carriers in the bulk of the material, the relaxation time of the charge carrier and the frequency of the applied electric field. The dielectric loss values decrease with increase in frequency.

Temperature (°C)	Pure Epoxy				Epoxy+5wt% orange Peel powder				Epoxy+10wt% orange peel powder			
	1 KHz	10 KHz	100 KHz	1 MHz	1 KHz	10 KHz	100 KHz	1 MHz	1 KHz	10 KHz	100 KHz	1 MHz
100	0.0939	0.0875	0.0938	0.0271	0.1839	0.0645	0.0438	0.0360	0.0139	0.0586	0.0448	0.0182
90	0.0893	0.0679	0.0857	0.0283	0.1693	0.0539	0.0377	0.0354	0.0194	0.0546	0.0376	0.0153
80	0.0635	0.0589	0.0426	0.0255	0.1562	0.0483	0.0351	0.0339	0.0098	0.0345	0.0287	0.0169
70	0.0447	0.0497	0.0394	0.0213	0.0887	0.0329	0.0236	0.0328	0.0077	0.0285	0.0197	0.0136
60	0.0344	0.0314	0.0280	0.0256	0.0663	0.0258	0.0189	0.0310	0.0058	0.0217	0.0135	0.0129

3.2.3 AC Conductivity

AC conductivity increases with increase in temperature for all the tested composites. The dielectric results of pure epoxy and epoxy/orange peel powder show different dielectric behaviours, depending on the frequency and on the imposed concentration. The frequency dependence of the dielectric properties emphasized low frequency dispersion for both orange peel powder and filled epoxy samples.

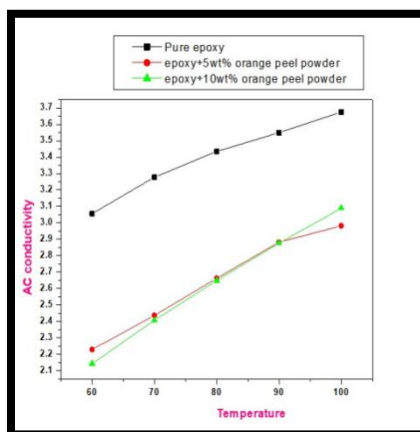


Fig.5: AC conductivity Vs Temperature at 1KHz

3.3 Thermal Analysis

Thermo Gravimetric Analysis

To study the thermal degradation characteristics of polymer composites thermo gravimetric analysis was employed using the thermal analyzer. TGA data of neat epoxy and orange peel powder-imposed epoxy composite (5 wt%, 10 wt %) were recorded and analyzed.

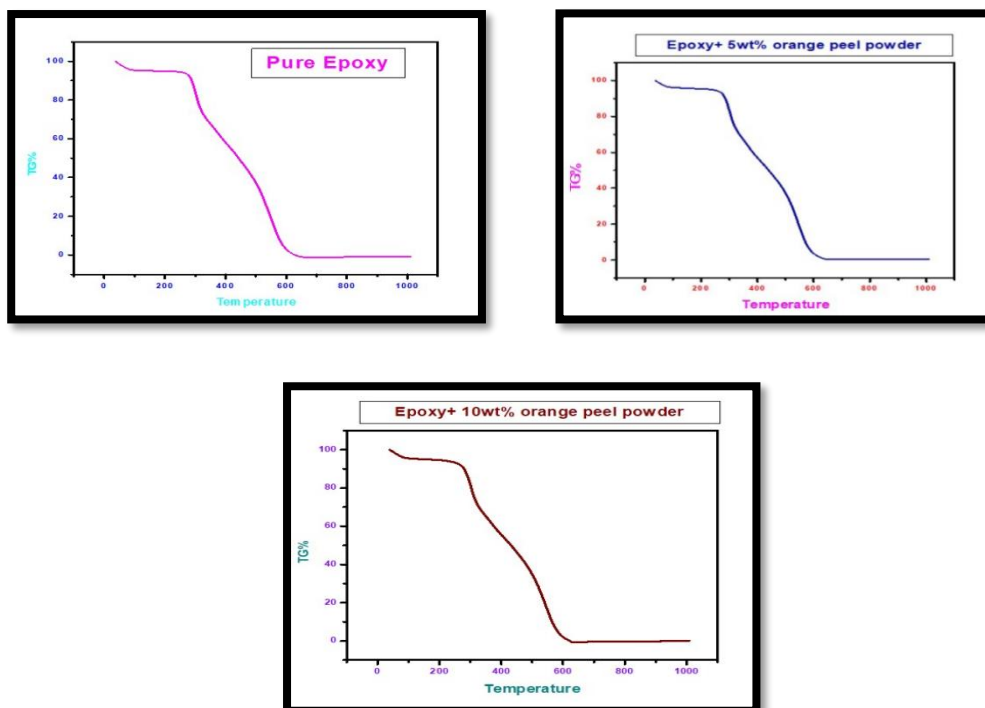


Fig.6: TG Graph of pure and orange peel-imposed epoxy

Conclusion

In this work, pure epoxy, epoxy + 5 wt% Orange peel powder and epoxy + 10 wt% orange peel powder was synthesized by solution casting method. The size of developed sheets is approximately 240×50×4 mm. FTIR study proved the occurrence of epoxy and amine hardener and interaction with imposed orange peel powder. The sharpness and intensity vary for different weight percentage orange peel added epoxy composites. A slight shift in absorption bands is observed for orange peel added epoxy system. The dielectric constant increases with the increase in temperature for all the tested composites. Orange peel powder- imposed epoxy showed low dielectric loss when compared with pure epoxy. The AC conductivity gets decreased by adding fillers into the epoxy. Thermo gravimetric analysis exhibited the double stage decomposition for pure and imposed orange peel epoxy which also showed that the amount of filler increases, the thermal stability also increases with filler loading.

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Physico-Chemical and Thermal Analysis of Sodium Acetate Treated *Cocos nucifera* Fibres

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ABSTRACT

Recent years have seen an increase in the utilization of petroleum resources, while environmental rules have prompted research on composite materials that are renewable, recyclable, and biodegradable. From domestic to aerospace items, natural fibre reinforced with polymers is employed in a wide range of applications. Before being reinforced, plant fibres need to be studied thoroughly. In the present work, sodium acetate treated coir fibre is studied by exposing it to various physical, chemical and thermal characterization analysis. Physical characteristics such as diameter, density, linear density, aspect ratio, thermal conductivity and water absorption were found. The diameter of the treated coir fibre was 533 μ m. Aspect ratio of the treated fibre was found out. Thermal conductivity of the treated fibre was 0.041132 W/mK. The density of the treated fibre was 1.16 g/cm³. The water absorption behaviour of treated fibres was very much reduced when compared to untreated coir fibres. The treated coir fibre has high cellulose content of about 60.39%. The activation energy of treated coir fibre was 56.3755 KJ/mol. The mass loss of treated fibre in all cases was below 352 °C. Coir fibre has many properties and is eco-friendly and so it can be concluded that it can be used as reinforcement in bio composites for various applications.

Keywords: Renewable, Sodium acetate, Coir, Cellulose, Bio composites

1. Introduction

Natural fibres have a number of advantages over conventional reinforcement materials, including adequate specific strength, low cost, low density, and improved thermal and acoustic insulating qualities [1]. Natural fibres are a form of substance that resembles hair and are either permanent fibres or only come in clearly lengthy pieces, like lengths of thread. The final part's properties like strength and stiffness are improved while the weight is reduced because of the high tensile strength of the fibres in a composite that are held together by the matrix resin. Natural fibre is created or produced using both plant and animal hair [2]. Due to its higher specific strength, biodegradability and lack of itching, less natural fibre issues during manufacturing as compared to synthetic fibre, is now used more frequently in polymer matrix composites. The benefits of using natural fibre-based composites in a variety of applications are increasing [3]. The two main factors that favour the use of natural fibres as

reinforcements are reduced mass fraction and density. The structural design of a product, which is predominately made of synthetic materials, is a significant component that affects its use and availability on the market. With their capacity to bend to a variety of designer configurations, natural fibre composites are now setting trends.

2. Materials and Methods

The Coconut fibres are extracted from the outer shell of coconut. The common name of the coconut fibre is coir. Scientific name is *Cocos nucifera*. The traditional method of retting is used to extract the coconut fibres. Fibre extraction or the separation of firmly linked fibres, can be accomplished manually or mechanically. The *Cocos nucifera* is collected from the village of Authivilai, Kanyakumari district of Tamil Nadu, South India. Fig. 1(a) shows the experimental fibres collected. The fibre is extracted from the husk and they are cleaned in distilled water and it is chemically treated. The treatment involves soaking the fibres in 0.1M of NaOH for 10 minutes and the fibres are drained. The drained fibres are soaked in a solution of sodium acetate for 20 minutes. Fig. 1(b) shows the experimental fibres under treatment. Then the fibres are dried in shade. Fig. 1(c) shows the experimental fibres are under drying process. After the fibres are dried, they are powdered for the purpose of characterization. This is done to determine how the treatment has altered their traits.



Fig. 1. Sodium acetate treatment of *Cocos nucifera* fibres

3. Results and Discussions

3.1. Physical properties of *Cocos nucifera* fibres

3.1.1. Length and Diameter analysis

The length is a crucial term used to find the linear density of the treated coir fibres. In order to determine the length, fifteen treated coir fibres are chosen. Using the ruler, the length of the fibre samples are measured. Finally, the average value is found out [4]. Similarly, microscope is used to find the diameter of the sample fibres. Table 1 shows the length and diameter of the sample.

Table 1. Physical properties of sodium acetate treated coir fibres

Parameters	Treated coir fibres
Length	19.94 cm
Diameter	533 μ m
Aspect ratio	374.101

Linear Density	1917 tex
Density	1.16 g/cc
Thermal Conductivity	0.041132 W/mK

3.1.2. Aspect Ratio

A higher aspect ratio is required for more efficient energy transmission between the matrix and fibre filaments upon impact. Because of their higher tensile strength, natural fibres with a high aspect ratio are advised. Fifteen fibres from *Cocos nucifera* samples that are sodium acetate treated are measured for their average diameter and length. The aspect ratio is found and is tabulated in Table 1. The following formula is used to find the aspect ratio of the natural fibre.

$$\text{Aspect Ratio} = L/D$$

Where L is the average length of the fibre and D is the average diameter of the fibre.

3.1.3. Linear Density

The linear density of the fibre is defined as the mass per unit length of the fibre. The values are tabulated in Table 1. The linear density of the treated coir fibre is calculated using the formula,

$$\text{Linear Density} = M/L \text{ g/km}$$

Where M is the average mass of the fibres; L is the average length of the fibres [4].

3.1.4. Density using Pycnometer

Density is the important parameter of natural fibres. When employing a fibre as reinforcement in a composite, the density of the fibre is an essential factor in determining the fibre's potential to be a lightweight material [5]. The density of the treated coir fibre is tabulated in Table 1. The density of the treated coir fibre is calculated using the formula,

$$\rho_{\text{cnf}} = \frac{(m_2 - m_1)}{(m_3 - m_1) - (m_4 - m_2)} \rho_b$$

Where m_1 is the mass of dry empty pycnometer (g); m_2 is mass of pycnometer + fibre (g); m_3 is mass of pycnometer + benzene (g); m_4 is mass of pycnometer + benzene + fibre (g); ρ_b is density of benzene (0.876 g/cm^3); ρ_{cnf} is density of sodium acetate treated *Cocos nucifera* fibre in g/cm^3 .

3.1.5. Thermal conductivity using Lee's Disc

Lee's Disc instrument is used to find the thermal conductivity of the coir fibre. The ability of a material to transfer or conduct heat is known as thermal conductivity. The thermal conductivity of the treated coir fibre is tabulated in Table 1. The following formula is used to find the thermal conductivity of the natural fibre:

$$K = \frac{mc(dT/dt) \times \frac{R+2h}{2(R+h)}}{\pi R^2 (T_2 - T_1)} \text{ W/mK}$$

K is the coefficient of the thermal conductivity of the sample; m is the mass of the metal disc; c is the heat capacity of the metal disc; dT/dt is the rate of cooling of metallic disc; X is the thickness of the sample; (T₂-T₁) is the temperature difference over the thickness of the sample; R is the radius of the sample; h is the thickness of the metal disc. The graph is plotted time along the x axis and temperature along the y axis.

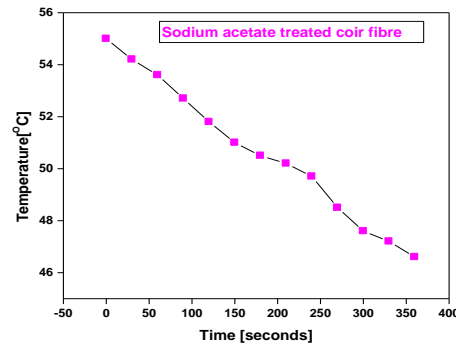


Fig. 2. Thermal conductivity of sodium acetate treated coir fibres

3.1.6. Water absorption behaviour

Studying the moisture absorption behaviour of composites made of natural fibres is crucial to comprehend the durability of composites based on the application sector. Water absorption of treated and untreated coir fibres is calculated using the formula,

$$\text{Water Absorption \%} = \frac{\text{Weight after immersion} - \text{Weight before immersion}}{\text{Weight before immersion}} * 100 \%$$

The graph is plotted with time in x-axis and percentage of water absorption in y-axis. Fig. 3 shows the graphical data of untreated and sodium acetate treated coir fibre.

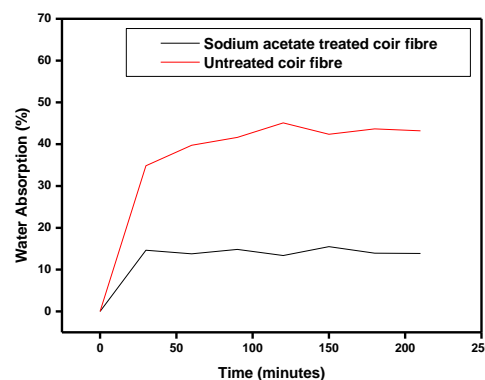


Fig. 3. Water absorption vs time graph of sodium acetate treated coir fibres

3.2. Chemical Analysis

The weight percentages of the different parts of a natural fibre, such as cellulose, lignin, wax, ash, moisture, pectin, and hemicellulose are found and are tabulated in Table 2 [6]. The physical and chemical treatments of plant fibers are known to change the cellulose

content as well as degree of crystallinity. The amorphous content gets washed away due to chemical treatment with increasing the ratio of crystalline to amorphous regions. Thus, cellulose content of coir fibre increases after treatment. To assess the chemical make-up of each fibre sample traditional analytical techniques are applied [4].

Table 2. Chemical composition of sodium acetate treated coir fibres

Chemical Composition	Untreated coir fibres [7]	Sodium Acetate treated Coir fibres (%) (present work)
Cellulose	37	60.39
Hemicellulose	-	31.61
Lignin	42	24.19
Pectin	-	3.98
Moisture	11.36	11.37
Wax	-	0.88
Ash	-	2.77
Density(g/cc)	1.2 [8]	1.16

3.3. Thermal Analysis

Thermal analysis is one of the most well-known and frequently employed methods for analysing the decomposition of solid materials. Depending on the nature and chemical makeup of the natural fibres, the heat degradation takes two to three processes. TG plot is generated with the temperature along the x-axis and the weight loss percentage along the y-axis. Table 3 indicates the mass loss of treated fibre in all cases below 352°C. Major mass loss (30 - 50 wt%) occurs above 243°C and is caused by the breakdown of crystalline cellulose.

Table 3. Thermal study of sodium acetate treated coir fibre

Fibre Type	Temperature during mass loss (°C)	Mass Loss	Residual mass At 700 °C (%)	Activation Energy (kJ/mol)
Treated coir fibre	0 - 154	4%	22.42%	56.3755
	154 - 243	2%		
	243 - 352	49%		

The highest peak of deterioration is identified using the DTG curve. The peak values on the TG curve are consistent with it. As a result, the thermal stability of the fibre has been perfectly evaluated. Table 4 examined the mass loss at T_{max} of treated coir fibres. DSC profiles of treated coir fibres are indicated in Fig. 4 (c). The treated coir fibre's lignified compartment is released by an exothermic peak at 361 °C [9].

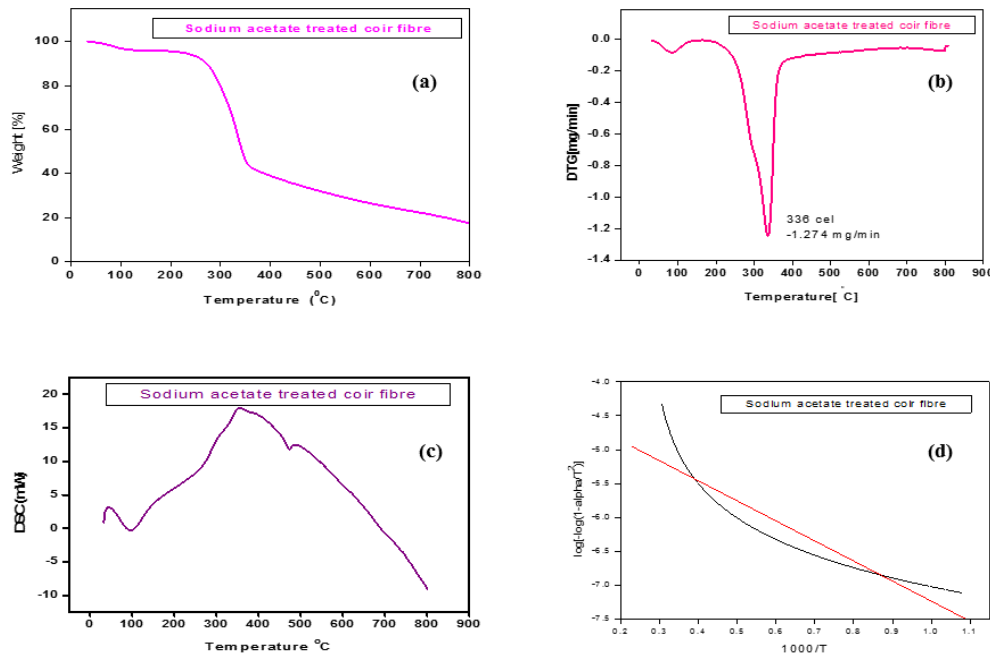


Fig. 4 (a) TG curve of sodium acetate treated coir fibres (b) DTG curve of sodium acetate treated coir fibres (c) DSC Curve of sodium acetate treated coir fibres (d)

Activation energy curve of sodium acetate treated coir fibres

The Activation energy of treated coir fibres is calculated from Coats - Redfern approximation.

$$\log\left[\frac{-\log(1-\alpha)}{T^2}\right] = \log\frac{AR}{\beta E_a}\left[1 - \frac{2RT}{E_a}\right] - \frac{E_a}{2.303 RT}$$

Table4. Mass loss at Tmax of treated coir fibres

Sample	Total mass loss (%)			Max. Temperature Limit (°C)	T (50%) (°C)
	First stage	Second stage	Third stage		
Treated coir fibre	4%	6%	55%	352	342

Conclusion

Coir fibre has many beneficial properties and is eco-friendly and so it can be concluded that it can be used as reinforcement in bio composites for various applications. The

sodium acetate treatment on this fibre material enhances its qualities and so it can be use in a variety of matrixes for many applications. In order to take care of our mother nature such natural fibre reinforced composites must be used rather than man-made fibre composites, since these composites are biodegradable even after its use.

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Single step synthesis of Copper Oxide Nanoparticles: A study on structural, optical, thermal properties and antibacterial effectiveness

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ABSTRACT

In the present work copper oxide (CuO) nanoparticles were synthesized by means of simple chemical precipitation method. Copper acetate and oxalic acid was used as precursors for this synthesis process. The prepared copper oxide nanoparticles were characterized by using X-Ray Diffraction (XRD) and Ultra Violet-Visible (UV-Vis) spectroscopic techniques. The phase and crystalline structures were determined using the XRD analysis. The optical band gap was analyzed by using UV-Vis Technique. The thermal properties of the nanoparticles were studied with the aid of Thermo Gravimetric Analysis (TGA). The antibacterial actions of copper oxide nanoparticles were studied and the inhibition zones were examined around the disc is measured with transparent ruler in millimeters.

Keywords: Copper Oxide, UV Spectroscopy, XRD.

1. Introduction

The application of nanoparticles is rising due to their unique properties like small size, high surface to volume ratio, controlled release and higher bioavailability [1]. Metal oxide nanoparticles have been receiving considerable attention for their potential applications in optoelectronics, nanodevices, nanoelectronic, nanosensors, information storage and catalysis [2]. Copper oxide nanoparticles are relatively cheap, photo catalytic and stable regard to their chemical and physical properties. The potential application of CuO nanoparticles as anti-infective agents lies in their extremely high surface area and desirable crystal morphologies [3, 4]. The highly ionic copper oxide nanoparticles effectively target a wide range of bacterial pathogens associated with nosocomial infections. However, a significantly high dose of copper oxide is required to generate an antimicrobial effect [5, 6]. Copper oxide is a well-known semiconductor materials has been considered as a important one because of their practical importance in electronic and optoelectronic devices, such as electrochemical cells, gas sensors, magnetic storage devices and catalysts etc. [7-10]. Because of their simplicity of preparation, scalability, nontoxicity, abundance, low-cost, and environmental friendliness,

CuO is a semiconducting compound with a narrow band gap and is used for photoconductive and photo thermal applications [11, 12].

In the present work, our aim is to the synthesis copper oxide nanoparticles in a single step by the simple chemical precipitation method. The novelty of the work is synthesis of copper oxide nanoparticles by one step reaction of copper acetate and oxalic acid, no catalyst is used in synthesis process. Further the structural, optical, thermal properties and antibacterial effectiveness were analyzed using the characterization techniques.

2. Materials and Methods

Nanostructure materials have attracted a great deal of attention because of the physical, chemical, electronic and magnetic properties show dramatic change from higher dimensional counterparts and depends on their shape and size. Many techniques have been developed to synthesize and fabricate nanostructure materials with controlled shape, size, dimensionality and structure. The performance of materials depends on their properties. The properties in turn depend on the atomic structure, composition, microstructure, defects and interfaces which are controlled by thermodynamics and kinetics of the synthesis.

Copper oxide nanoparticles were prepared by a simple chemical method. The precursor used in the synthesis process is copper acetate and oxalic acid. 0.4 mole of copper acetate was dissolved completely in 50 ml of water and stirred well using the magnetic stirrer. Similarly, 0.4 Mole of oxalic acid was dissolved in 50 ml of distilled water. The solution was stirred well using magnetic stirrer until it dissolves.

The dissolved oxalic acid was added to the copper acetate little by little and stirred well for about 30 minutes. Then the solution was kept at room temperature for a day. The solution was washed using distilled water three times per day, washing process continues for five days. After washing, the solution was kept in hot air oven at 100°C to get dried. Then the dried solution was powdered and kept in muffle furnace for heating at 500°C and finally desired copper oxide nanoparticles was obtained.

3. Results and Discussion

The X-Ray diffraction pattern of copper oxide nanoparticles was recorded using X-Ray Diffractometer with TOPS Software of wavelength 1.54060 Å. The XRD pattern obtained for the as-prepared copper oxide was shown in fig.1. Various parameters such as angle 2θ , d-spacing, (h k l) and relative intensity data of copper oxide nanoparticles are tabulated in table 1.

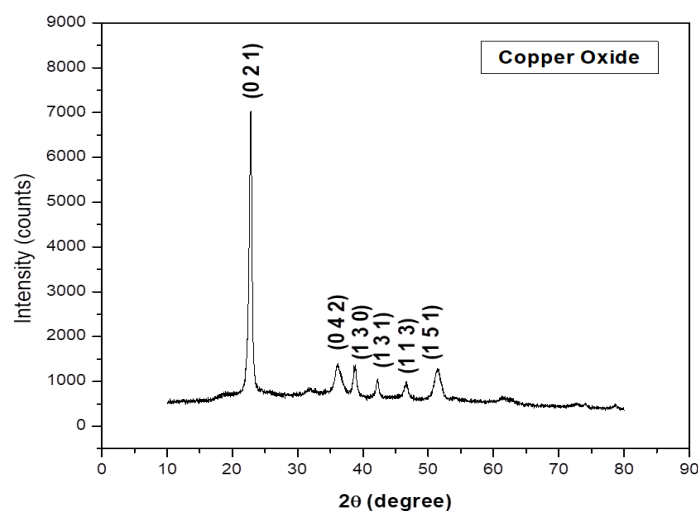


Fig.1. XRD pattern of as-prepared copper oxide nanoparticles

Table 1. Computed XRD parameters of copper oxide nanoparticles

S.No.	Angle 2θ (degree)	d-spacing (Å)	Net Intensity (counts)	Gross Intensity (counts)	Relative Intensity (%)	FWHM
1.	46.857	1.93735	170.956	810.540	4.1	0.353
2.	50.813	1.79541	225.635	860.781	5.4	0.100
3.	42.190	2.14025	257.961	907.564	6.1	0.254
4.	46.622	1.94659	265.577	908.028	6.3	0.350
5.	38.748	2.32205	366.863	1090.72	8.7	0.296
6.	36.097	2.48627	367.603	1139.87	8.8	0.100
7.	51.611	1.76953	374.864	1012.56	8.9	0.100
8.	51.407	1.77606	418.168	1056.23	10.0	0.100
9.	22.812	3.89520	4200.26	4970.51	100	0.284

The formation of CuO nanoparticles was confirmed by XRD analysis. All the diffraction peaks can be indexed with lattice planes and compared to the international center for diffraction data (ICDD) Card No: 41 - 0254. The d-spacing values of the present study were well matched with the reported values in the card given in table 2. In XRD analysis, the planes (1 1 2), (1 5 1), (1 3 1), (1 1 3), (1 3 0), (0 4 2), (3 1 1), (-2 0 2) and (0 2 1) indicate the

formation of monoclinic crystallite without having any peak due to the possible Cu_2O and $\text{Cu}(\text{OH})_2$ impurity. Therefore, from the XRD analysis it was further confirms that the prepared nanoparticles belong to CuO phase. The copper oxide nanoparticles retained its monoclinic structure with lattice parameters $a = 4.685 \text{ \AA}$, $b = 3.423 \text{ \AA}$, $c = 5.132 \text{ \AA}$, $\alpha = \gamma = 90^\circ$, $\beta = 99.52^\circ$ and $V = 81.17 \text{ \AA}^3$.

Table 2. Generated miller indices from ICDD

S.No.	Angle 2θ (degree)	d-spacing (\AA)	Miller Indices (h k l)
1.	46.857	1.93735	(1 1 2)
2.	50.813	1.79541	(1 5 1)
3.	42.190	2.14025	(1 3 1)
4.	46.622	1.94659	(1 1 3)
5.	38.748	2.32205	(1 3 0)
6.	36.097	2.48627	(0 4 2)
7.	51.611	1.76953	(3 1 1)
8.	51.407	1.77606	(-2 0 2)
9.	22.812	3.89520	(0 2 1)

UV - VIS spectrums of the prepared copper oxide nanoparticles were taken in the wavelength range between 200 to 800 nm. The spectrometer is initialized with glass plate and the sample is mounted for recording the absorption spectrum. UV spectra of the as prepared nanoparticles are taken using UV spectrophotometer [13, 14]. The optical absorbance spectrum is shown in fig 2.

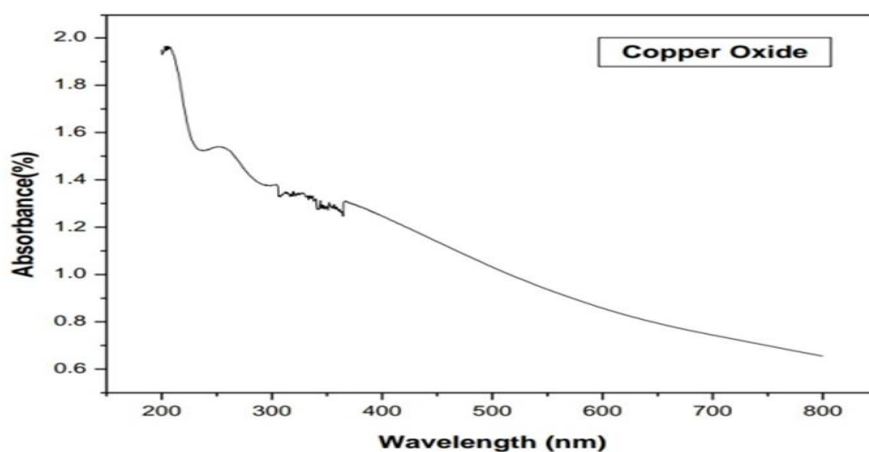


Fig 2. Optical absorbance spectrum for copper oxide nanoparticles

The optical absorbance spectrum of the synthesized copper oxide nanoparticles revealed a peak at 235 nm. The copper oxide absorbance peak shows maximum absorbance

of 1.95 % at 235nm. The energy band gap of copper oxide nanoparticle is obtained by the relation

$$E_g = h\nu = hc/\lambda$$

$$\lambda = 235 \text{ nm}; h = 6.62607 \times 10^{-34} \text{ Joules sec}; c = 3 \times 10^8 \text{ meter/sec.}$$

$$E_g = 5.29 \text{ eV}$$

The energy band gap of copper oxide is found to be 5.29 eV.

The thermal analysis of copper oxide nanoparticles is performed at the temperature range 0 to 1000°C in the normal nitrogen atmosphere. The TG/DTA pattern obtained for the as-prepared copper oxide was shown in fig.3 and fig.4.

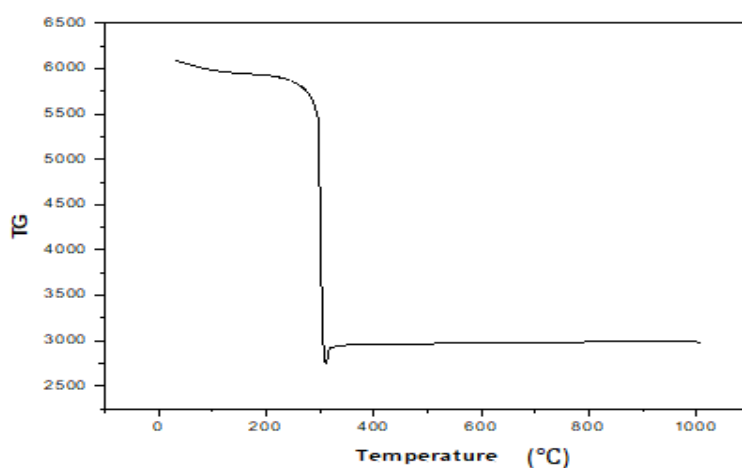


Fig.3 TG graph of copper oxide nanoparticles

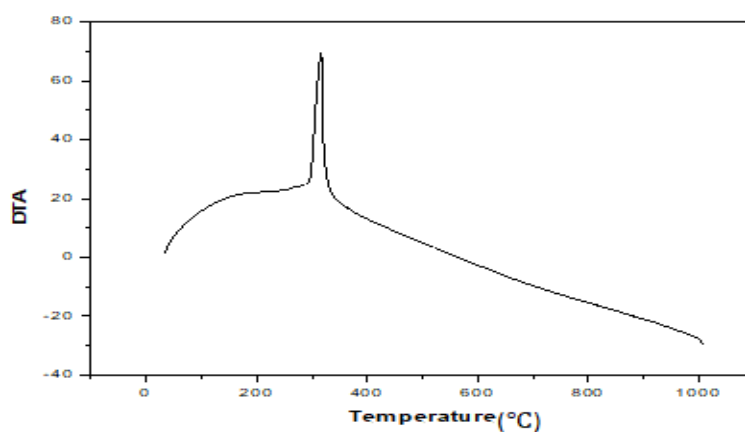


Fig.4 DTA curve of copper oxide nanoparticles

TG determines mass loss over a temperature range and DTA determine endothermic and exothermic temperatures and show phase transitions. The TG/DTA data for copper oxide nanoparticles shows that the exothermic peak takes place around 300°C which confirms that the material has retained its texture till 300°C without any decomposition up to this temperature. From the TG curve it was known that the prepared material experiences 100 percentage weight losses at 300°C due to the liberation of oxygen molecules this was confirmed by the DTA curve corresponding to the sharpen dothermic peakat 300°C. The final residue left behind is copper [15 - 17].

The application of nanoparticles as antimicrobial agents is gaining importance in the field of biology. The copper oxide nanoparticles have been synthesized and tested for various applications in medicine. Nanoparticles are increasingly used to target bacteria as an alternative to antibiotics. Nanotechnology may be particularly advantageous in treating bacterial infections. Examples include the utilization of nanoparticles in antibacterial coatings for implantable devices and medicinal materials to prevent infection and promote wound healing, in antibiotic delivery systems to treat disease, in bacterial detection systems to generate microbial diagnostics, and in antibacterial vaccines to control bacterial infections.

The antibacterial activity was tested on *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* bacterial strains. The qualitative assessment of the antibacterial effect was done using agar disc diffusion (Kirby Bauer) method. Bacterial strains were swabbed using sterile cotton swabs in Mueller Hinton agar plate. Up to 40 µl of each concentration of the extract were respectively introduced in the sterile discs using sterile pipettes. The disc was then placed on the surface of medium and the compound was allowed to diffuse for 5 minutes and the plates were kept for incubation at 37°C for 24 hours. The contact biocidal property can be determined by measuring the diameter of the zone of inhibition (ZOI) around the well. At the end of incubation, inhibition zones were examined around the disc and measured with transparent ruler in millimeters. The antibacterial effect of the copper oxide nanoparticles was qualitatively measured by performing agar diffusion test against all microorganisms. The diameters of the ZOI are determined and these are tabulated in Table 3. The absence of growth around the nanoparticles is an indirect measure of the ability of the material to inhibit the growth. The ZOI of the nanoparticles produced against the *Escherichia coli*, *Staphylococcusaureus* and *Pseudomonas aeruginosa* bacterial strains are shown in Figures 5 - 7.



Fig. 5. ZOI of the nanoparticles produced against *E. coli*



Fig.6. ZOI of the nanoparticles produced against *Staphylococcus aureus*



Fig.7 ZOI of the nanoparticles produced against *Pseudomonas aeruginosa*

Table. 3 Diameters of the ZOI produced by the samples against the microbes

S.No.	Microbes	Positive control Levofloxacin	Zone size in diameter(mm)
1.	<i>Escherichia coli</i>	27	10
2.	<i>Staphylococcus aureus</i>	22	12
3.	<i>Pseudomonas aeruginosa</i>	25	6

The antibacterial action of copper oxide nanoparticles against the *Escherichia coli*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* bacterial strains is studied. From the studies it was confirmed that the copper oxide nanoparticles are high antibacterial activity on *Staphylococcus aureus* bacteria.

3. Conclusion

In the present work, copper oxide nanoparticles are synthesized by a simple chemical precipitation method. The precursors used in the synthesis process were Copper Acetate and Oxalic acid. The preparation process is faster, cheaper and cost effective. The following conclusions are made from the result of this work. From the XRD characterization, it is observed that the prepared copper oxide nanoparticles belong to monoclinic crystal system. From the XRD spectrum, the corresponding phases are identified as CuO. From the TG/DTA studies, the thermal stability of the prepared copper oxide nanoparticles is identified as 300 °C. Furthermore, the chemical degradation of the material corresponding to the exothermic peaks is found out. The optical behavior of both copper oxide nanoparticles is studied by UV characterization. The band gap of the prepared nanoparticles is also found. The energy band gap of copper oxide nanoparticle is 5.29 eV. The antibacterial actions of copper oxide nanoparticles were studied and the inhibition zones were examined around the disc is measured with transparent ruler in millimeters. From the studies it was confirmed that the copper oxide nanoparticles are high antibacterial activity on *Staphylococcus aureus* bacteria. The future scope of the project is to analyze the particle size, SEM and TEM of the material.

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Synthesis of Nickel Hydroxide [Ni (OH)₂] Thin Film using SILAR Method

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ABSTRACT

In this report the nanostructured thin film of nickel hydroxide was obtained successfully by the SILAR method. The prepared samples were successfully characterized by different techniques namely X-ray diffraction (XRD), Fourier Transform Infrared Spectrum (FTIR), Field Emission Scanning Electron Microscope (FESEM), Energy dispersive X-ray analysis (EDAX), and the UV-Visible spectroscopy. Using the result of XRD reveals the presence of nickel hydroxide using nickel sulphate and nickel chloride by obtaining the peak value of 38.665° and 38.370°. In FTIR the formation of Ni-OH bonds which has proven by the appearance of the absorption bands at 3408 cm⁻¹ and 3371 cm⁻¹. The FESEM images shows the floral structure for nickel hydroxide which is prepared from nickel chloride and nickel hydroxide and containing different sized particle as 1 μm and 500 nm. The EDAX result shows that the sample is primarily composed of nickel, oxygen and hydrogen with the presence of other impurities. From the UV-visible spectra copy, the bandgap values were calculated and the values are 3.37eV and 3.16eV.

Keywords: Thin film, Nickel Hydroxide, SILAR

1. Introduction

Nickel hydroxide (Ni(OH)₂) has been widely used in numerous applications due to its unique physico-chemical properties. Because of the potential application of Ni(OH)₂ and the novel properties of nanoscale materials, considerable efforts have recently been focused on the preparation of nanostructured Ni(OH)₂, such as nanotubes, nanorods, nanosheets, and nanoribbons[1]. They were always mixed into conventional spherical Ni(OH)₂ to be used and could not independently used as the active materials in positive electrodes. Therefore, two- and three-dimensional Ni(OH)₂ hierarchical structures obtained by the self-assembly of low-dimensional building blocks have received increasing interest and can be independently used as the active materials in positive electrodes[2-4].

As two-dimensional nanoscale materials, nanostructured Ni(OH)₂ thin films are highly desired. Nickel oxide (NiO) thin films are very prosperous materials with excellent electrochromic properties. In this paper, nanostructured Ni(OH)₂ thin films were prepared by a SILAR process and the growth process as well as the structural and optical properties were discussed in detail.

2. Experimental Details

In this study, $[\text{Ni}(\text{OH})_2]$ nanostructures were grown by SILAR method on cotton cloth substrates at room temperature and ambient pressure. To synthesize the, $[\text{Ni}(\text{OH})_2]$ thin films, aqueous nickel-ammonia complexes ($[\text{Ni}(\text{NH}_3)_4]^{2+}$) were chosen for the cation precursor, in which using analytical reagents of NiCl_2 (% 99) and concentrated ammonia (NH_3) (25-28%) were used. The concentration values defined for the nickel (Ni) solution was 0.1 M and the molar ratio of Ni: NH_3 is 1:10 obtained as a result of several experiments.

For the synthesis of the, $[\text{Ni}(\text{OH})_2]$ thin films, one SILAR growth cycle included the following four steps

Step: (1) immersing the substrate in the complex ($[\text{Ni}(\text{NH}_3)_4]^{2+}$) solution for 40 s to create a thin liquid film containing ($[\text{Ni}(\text{NH}_3)_4]^{2+}$) on the substrate;

Step: (2) rinsing the withdrawn substrate immediately in double distilled water for 20s;

Step: (3) immersing the withdrawn substrate immediately for 60s in hot water at 100°C to form a $[\text{Ni}(\text{OH})_2]$ layer and

Step: (4) rinsing the substrate in a separate beaker for 20 s to remove large and loosely bound $\text{Ni}(\text{OH})_2$ particles. Thus one SILAR cycle of, $[\text{Ni}(\text{OH})_2]$ deposition was completed. By repeating such deposition cycles, 80 times we obtained, $[\text{Ni}(\text{OH})_2]$ films of the thickness 264 nm, respectively. The average growth rate was found to be 3.16 nm/cycle. The films were deposited at room temperature. To investigate the effect of film thickness on the characteristic parameters of the, $[\text{Ni}(\text{OH})_2]$ films, XRD, SEM and optical absorption measurements were used. For structural studies, X-ray Diffractometer with ($\lambda = 1.5405$ Angstrom (\AA)) radiation with 2θ of $20^\circ - 80^\circ$ was used. The surface morphology was studied using a SEM. To study the optical properties of the films, absorption measurements were conducted using a Perkin–Elmer UV/ VIS Spectrometer with wavelength resolution better than ± 0.3 nm at room temperature.

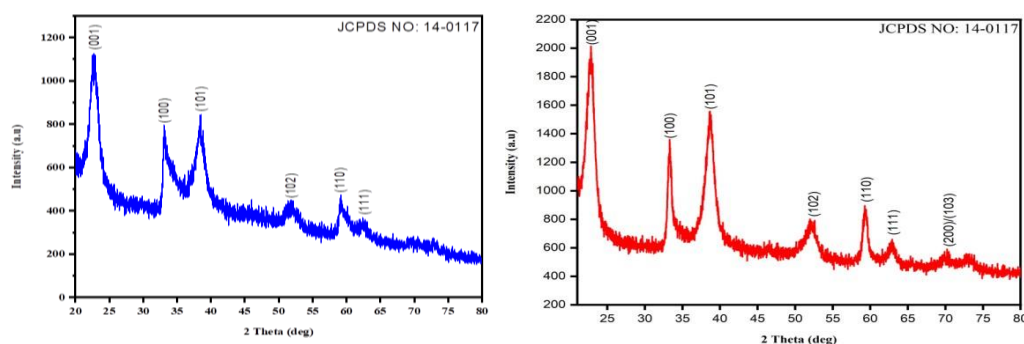
2. Results and Discussion

2.1. XRD analysis

In XRD the position and relative intensity of all diffraction peaks match with the JCPDS file no:14-0117 as shown in the Figure 1, Which indicate the presence of $\text{Ni}(\text{OH})_2$ nanoparticle. The average crystallite size of the nanoparticle was estimated from the line broadening of the diffraction line using Debye Scherrer's formula

$$D = K\lambda / \beta \cos\theta$$

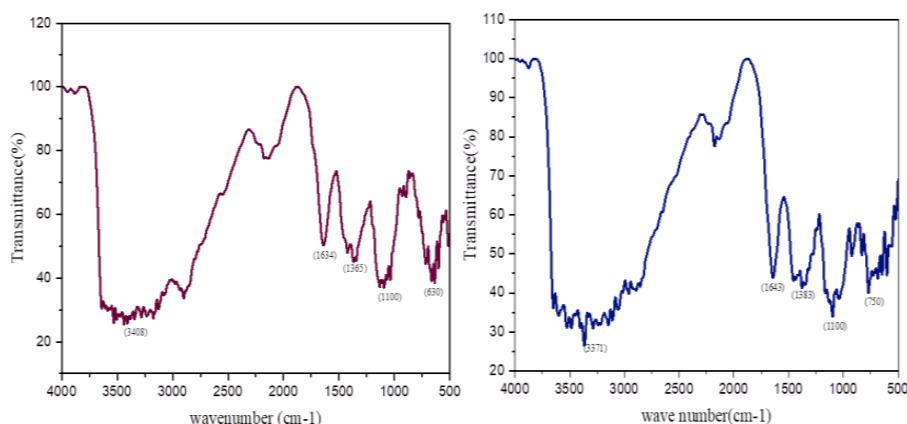
Where **D** is the average crystallite size (nm); **K** is the Scherrer's constant ($K=0.89$), λ is the wavelength of light used for diffraction ($\lambda=1.54056\text{\AA}$); β is the broadening of the diffraction peak measured at half of its maximum intensity (in radians) and θ is the Bragg's diffraction angle. The obtained peak value is (101) and the 2θ value is 38.370° using the solution Nickel Sulphate is shown in Fig. 1a and the peak value is (101) and the 2θ value is 38.655° is obtained for the solution Nickel Chloride is shown in Fig. 1b.



**Fig .1 XRD Pattern of Ni(OH)₂ nano structured thin film prepared using
a) Nickel Sulphate b) Nickel Chloride**

2.2. FTIR Spectra

The FTIR spectrum of Ni(OH)₂ shows a hydroxyl stretch from the Ni(OH)₂ lattice is between and an -O-H stretch of the intercalated hydroxyl group from water between 3100 and 3500 cm^{-1} . Also, an H-O-H bend is observed at 1605 cm^{-1} from the vibration of free water molecules. The spectrum also shows a sharp O-H stretch at 608 cm^{-1} from the hydroxyl lattice vibration and a weak peak at 467 cm^{-1} indicating a Ni-O lattice vibration.



**Fig.2: FTIR spectra of Ni(OH)₂ nanostructured thin films prepared using
a) Nickel Chloride b) Nickel Sulphate**

3.3. UV-VIS Spectroscopy

To characterize the absorption properties of the synthesized samples, UV-Vis

absorption spectrophotometer was used. UV-Vis spectrophotometers measure the absorption or transmission of light that passes through a medium. It offers a maximum absorbance peak. The optical bandgap energy can be determined by the following equation

$$E_g = hc / \lambda$$

where h is the Planck's constant (6.626×10^{-34} J-s), c is the velocity of light (3×10^8 m/s), λ is the corresponding absorption wavelength. The bandgap of $\text{Ni}(\text{OH})_2$ is 3–3.5 eV. The absorbance spectra of the synthesized $\text{Ni}(\text{OH})_2$ from nickel sulphate which exhibits a maximum peak at 368 nm with absorbance 0.567 (arb. Units). The optical band gap is found to be 3.37 eV.

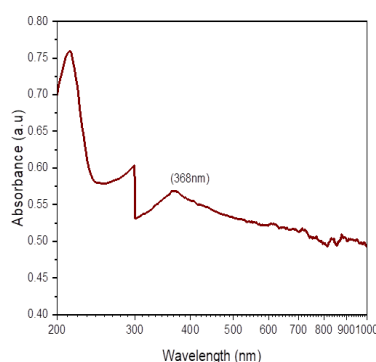


Fig.3: Absorbance spectra of $\text{Ni}(\text{OH})_2$ nanostructured thin films prepared using
a) Nickel Chloride b) Nickel Sulphate

3.4. FESEM Analysis

The FESEM images of $\text{Ni}(\text{OH})_2$ synthesized from nickel chloride, nickel sulphate annealed at 100°C are shown in Fig.4 & 5. The floral morphology with different size was observed.

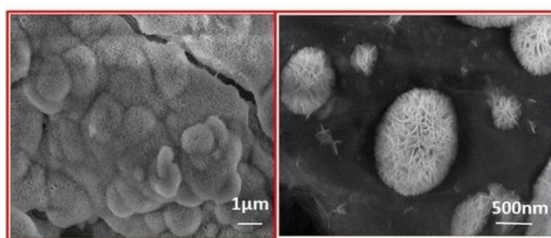


Fig.4. Morphology of $\text{Ni}(\text{OH})_2$ nanostructured thin films prepared using Nickel Chloride

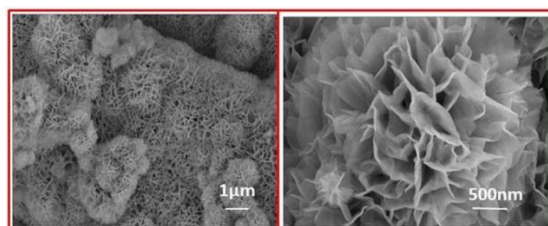
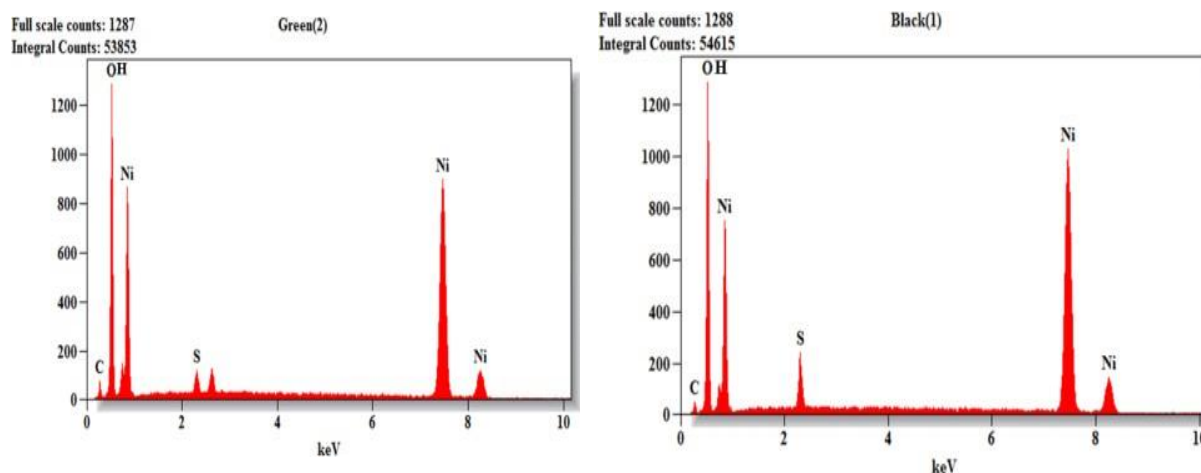


Fig.5: Morphology of $\text{Ni}(\text{OH})_2$ nanostructured thin films prepared using Nickel Sulphate

4.5. Energy Dispersive X-Ray Analysis (EDAX)

The elemental analysis of nickel hydroxide was done by energy dispersive X-ray analysis (EDAX). The energy dispersive X-ray analysis was conducted by focusing an electron beam several different sectioned regions of $\text{Ni}(\text{OH})_2$. The composition of sample shows the presence of nickel, oxygen and carbon elements. The peaks observed in the spectrum reveals the presence of Ni and OH, which confirms the formation of $\text{Ni}(\text{OH})_2$ in the sample.



**Fig.6: EDS spectra of $\text{Ni}(\text{OH})_2$ nanostructured thin films prepared using
a) Nickel Chloride b) Nickel Sulphate**

Conclusion

The nanostructured thin film of nickel hydroxide was obtained successfully by the SILAR method. XRD analysis confirms the crystal structure of $\text{Ni}(\text{OH})_2$ nanostructured thin films. The formation of Ni-OH bonds is proven by the appearance of the absorption bands at 3408 cm^{-1} and 3371 cm^{-1} observed in the FTIR. The FESEM images show the floral structure for nickel hydroxide which is prepared from nickel chloride and nickel hydroxide and containing different sized particles as $1\mu\text{m}$ and 500 nm . The EDAX result shows that the sample is primarily composed of nickel, oxygen and hydrogen with the presence of other impurities. The band gap values were calculated from absorption spectra and the values are 3.37 eV and 3.16 eV .

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Development of Nickel Oxide Nanospikes Using Sol-Gel Method

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ABSTRACT

NiO nanoparticles were synthesized by Sol-Gel method and the synthesized nanoparticles were calcined at different temperatures. The powders were investigated with X-ray diffraction, Scanning Electron Microscopy with EDAX analysis, UV-visible spectroscopy and Fourier Transform Infrared Spectroscopy (FTIR). The structural characterization was carried out by x-ray diffraction which confirms the polycrystalline nature of the films with a cubic structure. SEM analysis of the films enabled the conclusion that the prepared films are uniform, rough, large crystals and agglomeration of particles were observed. The UV studies shows the absorption properties of the synthesized nanoparticles. The stretching vibration of bonds of synthesized NiO nanoparticles were found from FTIR spectra.

Keywords: Nickel Oxide, XRD, UV-Visible spectroscopy, FTIR, SEM

1. Introduction

Nickel oxide is a p type 3d transition metal oxide and has received a great deal of attraction due to its applications in various fields such as electrochromic films, fuel cell electrodes and gas sensors, battery cathodes, PN hetero junctions, magnetic materials, photovoltaic devices, electrochemical supercapacitors, smart windows and dye-sensitized photocathodes [1-4]. With the volume effect, the quantum size effect and the surface effect, NiO nanoparticles are expected to possess many improved properties and even more attractive applications than those of bulk-sized NiO particles [5-7]. Preparation of Nickel involves the solution phase chemistry route, which in theory should provide multiple, simple ways to control the morphology, particle size and desirable crystalline phase [8-10]. The Nickel Oxide nanoparticles have been prepared by sol gel method with different calcination temperature. The synthesized Nickel Oxide nanoparticles synthesized were characterized through XRD, SEM, EDAX, UV-Vis spectroscopy and FTIR.

2. Experimental Procedure

0.2 M of Nickel Nitrate is dissolved in 50 ml of ethanol and isopropyl alcohol. The precursor solution is allowed to stir until clear solution is formed. Then the Sodium Hydroxide was added drop by drop to reach the pH value of 9. The sol is formed and the

temperature was set above 70°C in the magnetic stirrer. After 2 hours the green colour gel was formed and it is washed with ethanol for 3-5 times to remove by products and unreacted compounds. The gel is then placed in hot air oven at 100°C for 24 hours. The dried powder is then calcined in muffle furnace for different temperatures (300°, 500° and 700°C). After calcination process, the green coloured NiO nanoparticles changes into Black colour.

3. Results and Discussion

3.1 XRD analysis NiO nanoparticles

The powder X-ray Diffraction pattern of Nickel Oxide (NiO) nanoparticles was recorded using XPERT-PRO Diffraction system with $\text{CuK}\alpha$ radiation of wave length 1.54056Å. The characteristic powder X-ray diffraction pattern of nickel oxide nanoparticle susing different temperatures are shown in the fig.1

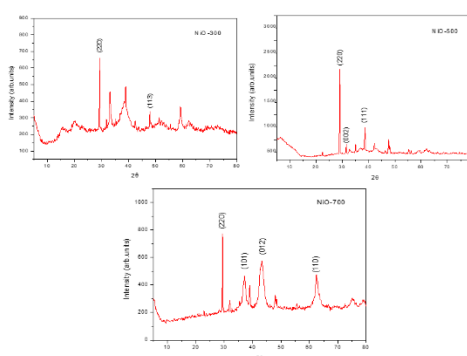


Fig.1 XRD analysis of NiO nanoparticles calcined at different temperatures

(a) 300°C (b) 500°C and (c) 700°C

Figure 1(a) shows the XRD pattern of NiO nanoparticles calcined at 300°C. The predominant peaks lie in (220) and (113) plane. The average grainsizes of NiO nanoparticles obtained in this process is 107.85 nm. Figure 1 (b) shows that XRD pattern of NiO nanoparticles calcined at 500°C. The predominant peaks lie in (220), (002) and (111) plane which indicates the good crystallinity of the sample. The average grainsizes of NiO nanoparticles obtained in this process is 40.26 nm. Figure 1(c) shows that XRD pattern of NiO nanoparticles calcined at 700°C. The predominant peaks lie in (220), (012), (101), and (110) plane which indicates with high intensity. The average grain size of the particle is found to be 33.52 nm. All the samples show the cubic structure which is in agreement with JCPDS file no. 89 - 7101. As the calcination temperature increases, there is a decrease in its grain size. Also. The calcination temperature makes the peak intense and clear.

3.2 UV-Visible analysis

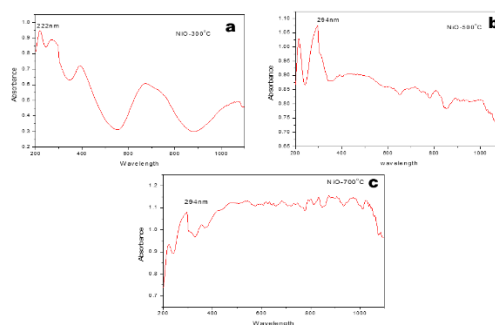
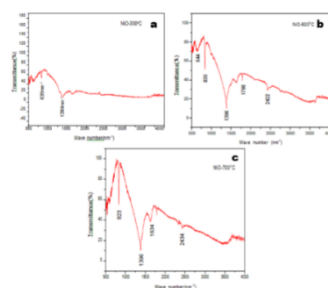


Fig.2 UV-Visible analysis of NiO nanoparticles calcined at (a) 300°C (b) 500°C (c) 700°C

Figure 2 shows the optical absorption spectra of the NiO nanoparticles synthesized with different calcination temperature. A strong absorption peak is obtained in the UV region at 270 nm, 294 nm and 294 nm wavelength respectively, which may be associated to the absorption band of NiO. The bandgap value is found to be 3eV, 3.2 eV and 3.2 eV respectively for the optimized synthesized NiO nanoparticles calcined at different temperatures.

3.3 FTIR Analysis

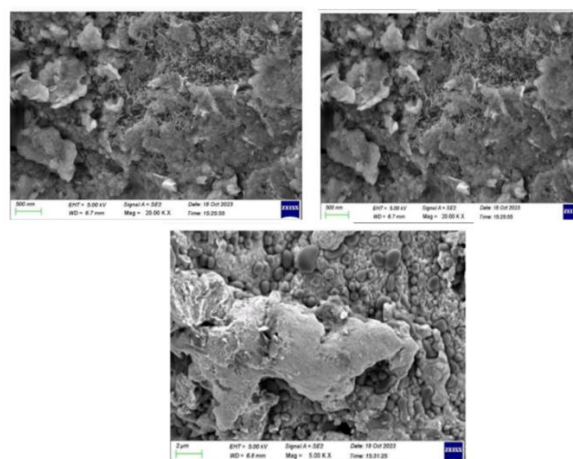
FTIR Analysis measures the infrared region of the electromagnetic radiation spectrum, which has a longer wavelength and a lower frequency than visible light. This spectrum is measurable in a sample when submitted to infrared radiation (IR). The basic theory at work is that the bonds between different atoms absorb light at different frequencies. The FTIR analysis results for Nickel Oxide nanoparticles at various different temperatures at 300°C, 500°C, 700°C.



**Fig 3. FTIR spectra for NiO nanoparticles synthesized at 300°C
(b) 500°C (c) 700°C**

3.4 SEM Analysis

Scanning electron microscopy-energy dispersive X-ray analysis (SEM-EDX) provides a quick nondestructive determination of the elemental composition of the sample readily identifying barium, potassium, strontium, and chlorine.

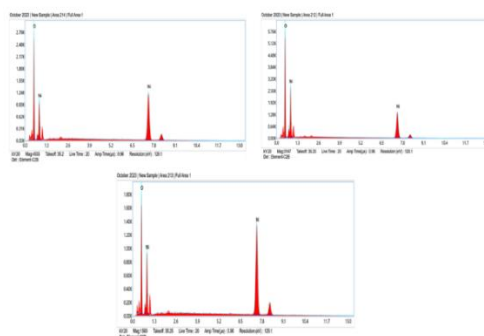


**Fig 4. FESEM spectra for NiO nanoparticles synthesized at
(a) 300°C (b) 500°C (c) 700°C**

The NiO nanoparticles synthesized with 300°C and 500°C of calcination temperature show nanospikes and as the temperature increased to 700°C nanopebbles were formed.

3.5 EDX analysis

EDX measurement evidences that NiO contain only Ni and O elements and there is no trace of any other impurities within the detection limit of the EDX. In addition, there was no evidence of impurities or residues observed in the EDX results, which also confirmed the complete formation of NiO nanostructures.



**Fig 5. EDX spectra for NiO nanoparticles synthesized at
a) 300°C (b) 500°C (c) 700°C**

Element	Weight %		
	300°C	500°C	700°C
O K	41.87	31.06	54.60
Ni K	58.13	68.94	45.40

Conclusion

In this report, nickel oxide (NiO) nanoparticles are synthesized by sol-gel method. The procedure developed in the present study offers homogeneous particle distribution, good reactivity between components, nano-size particles and allow slower processing temperature. Using Debye Scherer's formula, the average grain size of NiO was found to be 107.84 nm, 40.25 nm and 33.52 nm respectively for samples calcined at (a) 300°C (b) 500°C (c) 700°C. The UV studies show that there is a blue shift exhibited by NiO nano crystalline particles. The FTIR spectra of the synthesized nanoparticles reveal the stretching vibration of different bonds. The SEM analysis shows the nanoparticles synthesized are of nanospike shaped and the EDS results are shown in the graph. The EDS results show the purity of the synthesized NiO nanospikes and confirm that no impurities are present. Hence the synthesized (NiO) Nickel oxide powders are used as an electrolyte in nickel plating solutions, an oxygen donor in auto emission catalysts. Also, they can be used in anodizing aluminum, conductive nickel zinc ferrites, in glass frit for porcelain enamel, thermistors, cermet and resistance heating elements.

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Copper Ferrite Thin Film Fabricated using the Doctor Blade Method: Synthesis and Characterization

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ABSTRACT

Copper ferrite thin film has been prepared by using doctor blade method and it finds application as a dye-sensitized solar cell, which is a third-generation photovoltaic device that holds significant promise for the inexpensive conversion of solar energy. For the fabrication of the thin film, CuFe₂O₄ nanoparticles synthesized via green route using egg white are used. The structural characteristics of the synthesized thin film were studied by X-ray diffraction analysis, Fourier transform infrared spectrum was recorded to investigate the presence of the chemical substances in the synthesized copper ferrite thin film.

Keywords: Thin Film, Doctor Blade Technique, Ferrite, Nano, XRD, FTIR, Green.

1. Introduction

Due to their high electrical resistivity and excellent magnetic properties, spinel ferrites are excellent candidates for modern technological applications. Copper ferrite nanoparticles (NPs) are used in biomedicine (drug delivery [1], magnetic resonance imaging [2], magnetic cell separation, and DNA extraction [3]). They also have various technological applications such as energy storage devices [4], magnetic storage media [5], and spintronic and electromagnetic devices [6,7]. Furthermore, ferrites have been used as catalysts for the photocatalytic degradation of organic matter [8, 9, 10], oxidation of dimethyl ether [11] and mercury [12], and reduction of 4-nitrophenol [13]. The spinel structure of ferrites provides additional sites for the catalytic reaction, leading to an increase in the efficiency of photocatalytic decomposition [14,15].

Doctor blade coating is the most widely employed solution processing technique for large-area thin film fabrication at low cost. Doctor blade coating is a technique used to form films with well-defined thicknesses. The technique works by placing a sharp blade at a fixed distance from the surface that needs to be covered. The coating solution is then placed in front of the blade and the blade is moved across in-line with the surface, creating a wet film. The technique should ideally have solution losses of about 5%; however, practically, it takes time for optimal conditions to be found [16].

A dye-sensitized solar cell is a low-cost solar cell belonging to the group of thin film solar cells [17]. The DSSC has a number of attractive features; it is simple to make using conventional roll-printing techniques, is semi-flexible and semi-transparent which offers a variety of uses not applicable to glass-based systems, and most of the materials used are low-cost. Although its conversion efficiency is less than the best thin-film cells, in theory its price/performance ratio should be good enough to allow them to compete with fossil fuel electrical generation by achieving grid parity. Commercial applications, which were held up due to chemical stability problems, had been forecast in the European Union Photovoltaic Roadmap to significantly contribute to renewable electricity generation by 2020 [18, 19].

2. Experimental Details

The doctor blade technique to adopted in the fabrication of CuFe_2O_4 thin film in the present work. The CuFe_2O_4 nanoparticles required for the fabrication is synthesized via green synthesis route adopting solution combustion methods using egg white as fuel [20 -23]. In order to prepare the thin film, 1.494g of CuFe_2O_4 nanoparticles were mixed with 8.3 ml of liquid ethanol and 15 ml of distilled water and the mixer was stirred for 20 minutes. Then the precursor has been sonicated for 30 minutes, The pH level was optimized to 3 by adding nitric acid drop by drop. Using the glass rod, the sample in the paste form is spread uniformly throughout to the conducting side of the glass slide doesn't leaving any spots of the slide uncovered. Now the same process is repeated for three times and the thin film was annealed at 500°C furnace for 1 hour. After the completion of the above procedure the prepared thin film were characterized using XRD and FTIR.

3. Results and Discussion

3.1. XRD Analysis

The fabricated copper ferrite thin film was calcinated at 500°C for one hour and subjected to XRD analysis. The XRD pattern of the samples is shown in Fig. 1. They exhibit typical reflections planes (2 2 0), (3 1 1), (4 0 0), (4 0 0), (5 1 1) and (4 4 0) that are indications of the presence of the cubic spinel structure [24, 25]. These diffraction lines provide clear evidence on the formation of copper ferrite system. All the diffraction peaks match well with the reported values (JCPDS file No:25-0283).

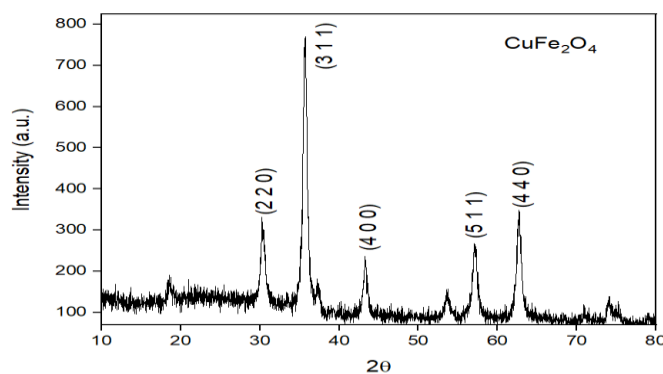


Fig. 1. XRD pattern CuFe₂O₄ thin film

Comparison of standard and observed 2θ values for CuFe₂O₄ nanoparticles

JCPDS 2θ (degree)	h k l	Experimental 2θ (degree)
30.168	220	30.408
35.641	311	37.335
43.038	400	43.340
57.052	511	57.135
62.775	440	62.704

3.2. FTIR Analysis

FTIR analysis of copper ferrite thin film

The FTIR spectra of copper ferrite thin film was analysed in two ranges of the absorption bands, 4000 - 1000 cm⁻¹ and 1000 - 400 cm⁻¹ and shown in Fig. 2. In the range of 4000-1000 cm⁻¹, vibrations of CO₃²⁻, NO₃³⁻ and moisture were observed. The intensive broad band at around 3400 cm⁻¹ and the less intensive band at around 1630 cm⁻¹ are due to O-H stretching vibration interacting through H bonds. Traces of adsorbed or atmospheric CO₂ are evidenced by the very small absorption peak around 2340 cm⁻¹. The ν (C=O) stretching vibration of the carboxylate group (CO₂²⁻) is observed around 1390 cm⁻¹ and the band at around 1100 cm⁻¹ corresponds to nitrate ion traces. In the range of 1000 - 400 cm⁻¹, two main metal - oxygen bands at around 560 and 450 cm⁻¹ were observed in the spectra of copper and zinc substituted spinel ferrite nanoparticles. The band at around 560 cm⁻¹ corresponds to intrinsic stretching vibrations of the metal at the tetrahedral site (Fe - O), whereas the band at around 420 cm⁻¹ is assigned to octahedral - metal stretching (Zn/Cu - O) [26 -28].

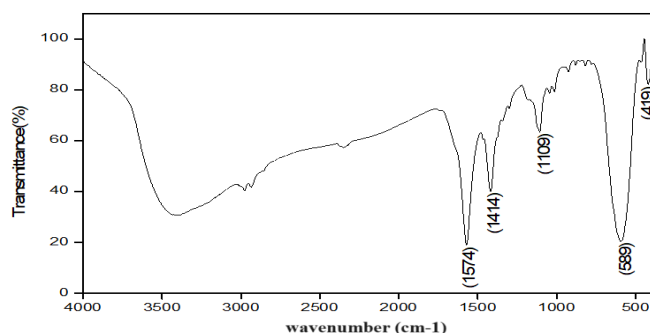


Fig. 2. FTIR pattern CuFe₂O₄ nanoparticles

3. Conclusion

Copper ferrite thin film has been prepared using doctor blade method. The synthesized thin film was characterized by powder XRD and FTIR techniques. The synthesized CuFe₂O₄ thin film was confirmed as copper ferrite system from the XRD analysis. The crystal structure of the copper ferrite thin film is found to be face centred cubic structure, from comparing XRD data with standard JCPDS file no. 25-0283. From the FTIR data, the organic and inorganic compounds and bands of them are found. The fabricated CuFe₂O₄ thin film can be used as sensors and for energy storage purposes.

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Synthesis and Characterization of Hydroxyapatite from Eggshell with *Carica papaya* Leaf Extract

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ABSTRACT

Hydroxyapatite (HAp) is a substance that is most actively used in orthopaedic dentistry as a bio coating of implants to improve its osteointegration with bone tissue. In this present study, the Pure and Extract added HAp was synthesized from Eggshell using the wet precipitation method. The characterization of the sample was done by using Powder X-ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), and UV Spectroscopy. As a result, the study showed that by using the precipitation method, HAp was able to be synthesized from eggshell waste.

Keywords: Hydroxyapatite, Eggshell, Calcination, XRD, FTIR.

1. Introduction

Hydroxyapatite is a ceramic material which forms the mineral phase of bone. It is comprised primarily of calcium and phosphate at a respective ratio of 1.67. HAp has been used extensively within the world of orthopaedics as a biomaterial to promote tissue regeneration. Nanoscale Hydroxyapatite (HAp) is a ceramic material that forms the mineral phase of bone. It is comprised primarily of calcium and phosphate at a respective ratio of 1.67. HAp has been used extensively within the world of orthopaedics as a biomaterial to promote tissue regeneration.

Nanoscale formulations of HAp have been investigated for both orthopaedic and dental tissue regenerative applications. When in its nanoscale formulation, this material has proven advantageous due to its rapid rate of resorption, which has been shown to result from its high solubility due to its nano crystallinity [1].

Nano hydroxyapatite (nHAp) has been studied extensively as a material coating for orthopaedic and dental implants, as well as for tissue-engineered scaffolds. Titanium implants have emerged as an important biomaterial for both orthopaedic and dental tissue engineering due to their bioinert properties. These implants have been coated with nHAp in an attempt to make them bioactive. nHAp coated on titanium implants can lead to improved mechanical strength at the tissue-implant interface [2].

With the reported success of HAp as an implant coating, nHAp is being incorporated into tissue-engineered scaffolds with the ultimate goal of improving orthopaedic and craniofacial tissue regeneration. The incorporation of nHAp into polycaprolactone (PCL)/gelatin nanofibrous tissue-engineered scaffolds for dental tissue engineering led to the up-regulation of odontogenic markers when compared to nanofibrous scaffolds without nHAp [3].

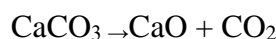
2. Experimental Methods

2.1 Egg Shell Pretreatment

The membrane attached to the inside of the eggshell was removed. Subsequently, the shell was washed with distilled water and dried at room temperature, and finally crushed until obtaining a particle size of less than 5nm.

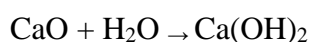
2.2 Calcination Test

A fixed amount of crushed eggshell (≈ 10 g) was placed in quartz crucibles and calcined for 2 hours in a static air atmosphere at 700°C temperature. Since the main component present in the eggshell is calcium carbonate (CaCO_3) the calcination reaction would proceed according to:

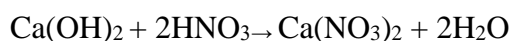


2.3 Synthesis of Hydroxyapatite

1) 2.8 g of CaO, obtained from the calcination of the eggshell, was dissolved in distilled water at 60 °C with constant stirring for 1 hour.



2) 20 ml of nitric acid (HNO_3) were added into calcium hydroxide solution, Ca(OH)_2 , until a clear liquid was obtained.



3) 4.0827 g of potassium dihydrogen phosphate, (KH_2PO_4), was prepared with 50 ml distilled water. This solution $\text{Ca(NO}_3)_2$ a precipitate is obtained with a molar ratio Ca/P = 1.67.

4) The $\text{Ca(NO}_3)_2$ solution was kept under constant stirring and the KH_2PO_4 solution was slowly added in the solution.

A dilute NH_3 solution was also slowly added at a rate sufficient to maintain a pHvalue ≈ 10 . The resulting solution was kept under constant stirring for at least 1 h and was subsequently kept at rest until complete separation of the precipitate was obtained (24 h). The precipitate was separated by filtration and washed with distilled water. The obtained precipitate was dried at 65°C for 24 h and heat treated for 30 min for 500°C. The same procedure was added

for extract-added hydroxyapatite where *carica papaya* Leaf Extract is added instead of distilled water as solvent. The X-ray diffraction of the samples was recorded and analyzed using a XPERT-PRO powder diffractometer with monochromatic CuK α radiation ($\lambda=1.5406$ Å) over the 2θ range of 20° to 80° . The FTIR spectra was recorded using FTIR spectrophotometer (Bruker IFS 48) The optical properties of the samples are studied using JASCO 650 UV Spectrophotometer.

3. Results and Discussion

3.1 Powder X-ray diffraction Analysis

Powder XRD is used for crystal phase identification and estimation of the crystallite size for synthesized nanoparticles. The PXRD pattern of pure and extract-added hydroxyapatite is shown in figures 1 and 2. All the diffraction peaks of the pure and Extract added HAp can be indexed hexagonal HAp (Space group $P6_3/m$) using JCPDS file no.09-0432, ($a=9.418$ Å, $c=6.884$ Å). All samples confirmed the presence of hexagonal structure and the Bragg peaks with miller indices (002), (210), (211), (300), (202), (310), (311), (113), (203), (222), (312), (213), (321), (004), (322), (313), (214), (304), (511), (215) and (513) were associated with the hexagonal lattice of HAp. The average crystallite size of the nanoparticle was estimated from the line broadening of the diffraction lines using Debye Scherrer's formula

$$D = \frac{0.9\lambda}{\beta \cos \theta}$$

Where, D is the average crystallite size (nm), λ is the wavelength of light used for diffraction ($\lambda=1.54056$ Å), β is the broadening of the diffraction peak measured at half of its maximum intensity and θ is the Bragg's diffraction angle. The average crystallite size of the pure and extract added Hydroxyapatite particles were found to be 80 and 60 nm respectively.

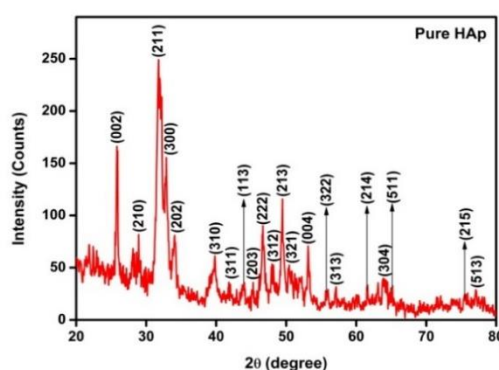


Fig.1 PXRD pattern of Pure HAp nanoparticle

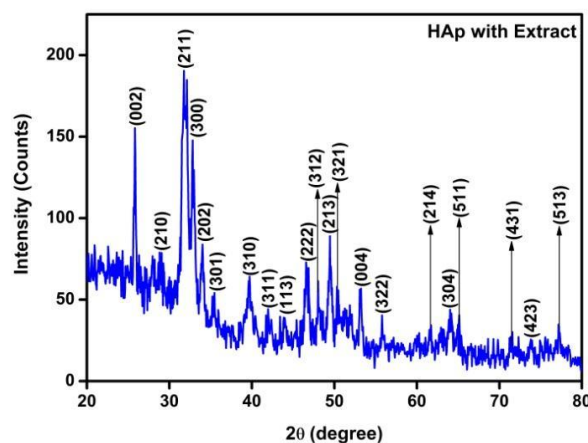


Fig.2 PXRD pattern of Extract added HAp nanoparticles

3.2 Fourier Transform Infrared Spectroscopy (FTIR)

The FTIR analysis was carried out to identify unknown species, functional groups, and vibrational modes associated with each peak. Fig 3 and 4 show the FTIR spectra of Pure and Extract added HAp nanoparticles. The bands observed at 573.56 cm^{-1} and 565.56 cm^{-1} were assigned to the O-P-O bonding mode. The bands observed at 1086.24 cm^{-1} and 1121.43 cm^{-1} were assigned to Asymmetric stretching of the mode of O-P-O and they appear large intensity. The increase in intensity Whereas the bands assigned at 1638.12 cm^{-1} and 1645.32 cm^{-1} are assigned to bending modes of H-O-H of lattice H_2O . The FTIR spectra confirm the formation of Pure and Extract added HAp and results are supported with XRD analysis. The OH broad peak at 3400 cm^{-1} is decreased for extract added samples due to decrease in crystallite size.

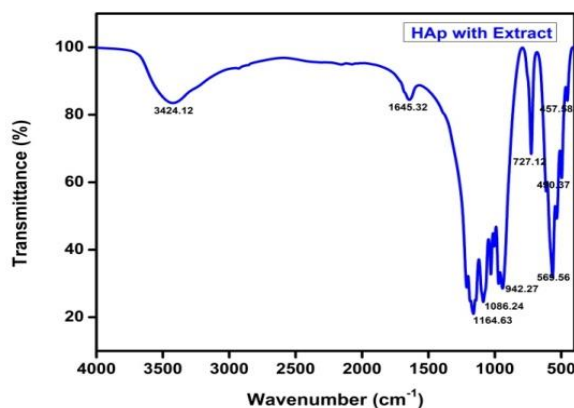


Fig.3 FTIR spectrum of Pure HAp nanoparticles

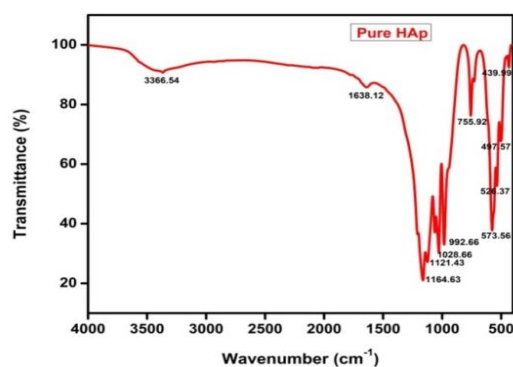


Fig.4 FTIR spectrum of Extract added HAp nanoparticles

Table 1: FTIR band assignments of Pure and Extract added sample Hapnanoparticles

S. No	Pure HAp (Wave number cm ⁻¹)	Extract added HAp (Wave number cm ⁻¹)	Band Assignment
1	3366.54	3424.12	O-H stretching mode
2	1638.12	1645.32	Symmetric bonding mode of H ₂ O
3	1164.63	1164.63	Asymmetric stretching of PO ₄ ³⁻
4	1121.43	1086.24	Asymmetric stretching of PO ₄ ³⁻
5	573.56	565.56	Asymmetric bonding of PO ₄ ³⁻

3.3 UV-Vis Studies from HAp Nanoparticle

UV absorption spectrum is analyzed for all samples from 200 nm to 800 nm. Peaks observed in the absorption spectra are due to transition of electrons between valance band, conduction band and intrinsic defect levels. This is the characteristic absorption peak of HAp which is ascribed to intrinsic band-gap absorption of HAp. When particle size increases visible absorption increases. This may be due to the increase in number of Oxygen vacancies. The spectrometer is initialized with glass and plate and the sample is mounted for recording transmittance and absorption. The optical band gap energy can be determined by the following equation,

$$E_g = hc/\lambda$$

Were,

- h is the Planck's constant (6.626×10^{-34} J-s).
- c is the velocity of light (3×10^8 m/s).
- λ is the corresponding absorption wavelength.

Fig 5 & 6 shows the band gap values of Pure and Extract added HAp nanoparticles and the same was given in table 2. The band gap values of Extract added HAp nanoparticles are found to be increased due to decrease in crystallite size.

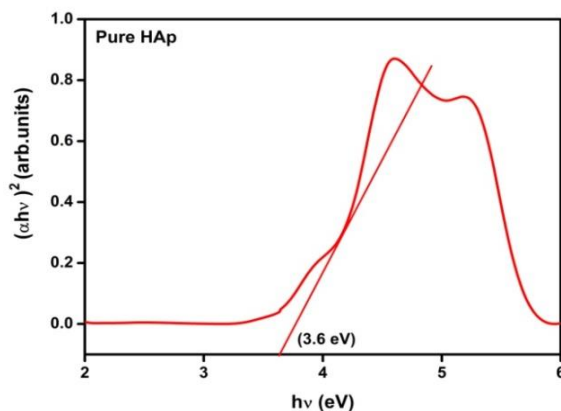


Fig.5 Optical absorbance spectra of Pure HAp nanoparticles

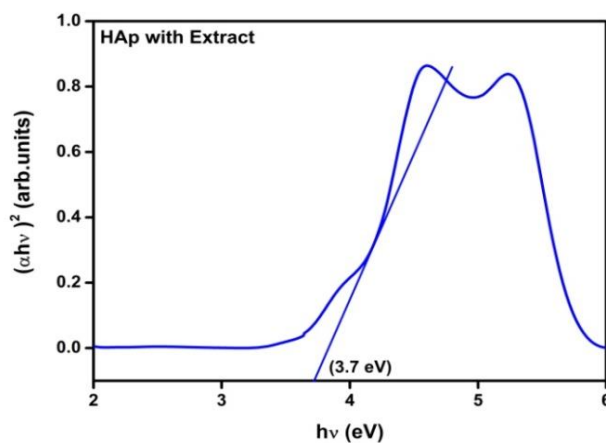


Fig.6 Optical absorbance spectra of Extract added HAp nanoparticles

Table 2: Optical band gap of Pure and Extract added HAp calcined at 500° C

S.NO	Nanopowder sample	Optical band gap (eV)
1	Pure HAp	3.6
2	Extract added HAp	3.7

4. Conclusion

In this present work, nano-sized pure and extract added Hydroxyapatite particles were successfully synthesized through wet precipitation method. The samples were characterized using PXRD, FTIR and UV Spectroscopy. The XRD spectra shows hexagonal structured HAp nanoparticles. In the FTIR spectra of pure and extract added hydroxyapatite shows the characteristic vibrational bands related to phosphate, hydroxyl and absorbed water were present. It can also be observed that adding of Extract with hydroxyapatite did not cause the appearance of any other additional vibrational bands associated with Extract or other impurities. From the UV spectra the band gap energy is increased for the Extract added HAp nanoparticles.

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Synthesis of Cobalt-Oxide Nanoparticle using Co-Precipitation Method

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ABSTRACT

In the present study, cobalt oxide (Co_3O_4) nanoparticles have been synthesized using cobalt nitrate as its source by precipitation approach. The structural properties of the synthesized Co_3O_4 nanoparticles were studied using X-ray diffraction (XRD). The XRD results confirm the crystalline nature of the nanoparticles. Further, scanning electron microscopy (SEM) was also performed to study the morphology of the synthesized Co_3O_4 nanoparticles. SEM micrograph shows that the Co_3O_4 nanoparticles are somewhat agglomerated sphere morphology.

Keywords: Co-Precipitation process, Co_3O_4 nanoparticle, FESEM.

1. Introduction

Syntheses and applications of metal and metal oxide nanoparticles have found paramount interest because of their unique properties due to their structure, dimension, morphology and size. Generally, transition metal oxides Co_3O_4 have been getting greater attention for electrochemical capacitor and sensor applications. Cobalt oxide (Co_3O_4), one of the transition metal groups metal oxide nanomaterials, is a good significant substance due to its exceptional characteristics and thermal permanence [1]. Characteristics as semiconducting, magnetic, optical, electrochemical, and electro-catalytic, cobalt oxide nanoparticles are widely used in heterogeneous catalysts, chemical sensors, photocatalytic hydrogen production, electrochromic devices, and energy storage systems [2,3]. Their enormous surface area and strong conductivity due to their nanoparticle size make them appropriate for catalysis. The cobalt oxide nanoparticles' high reversibility and ease of charge transfer during charging and discharging improve the device's performance [4]. Co-precipitation is a simple procedure that increases the size of nanoparticles while also controlling their development. The co-precipitation approach was used in this study to combine cobalt oxide nanoparticles for the purpose of electrochemically detecting blood cholesterol [5,6]. To the synthesis of cobalt oxide nanoparticles by simple chemical preparation method. The novelty of the work is the aqueous solution ammonium hydroxide is used for the synthesis process. Further the

structural, optical and morphological properties of the nanoparticles were analyzed using the characterization.

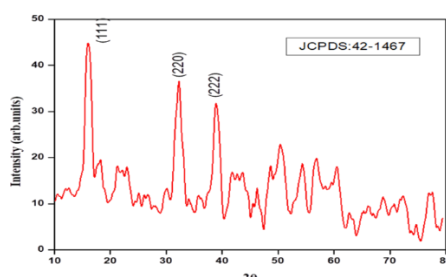
2. Experimental method

In the present work co-preparation process has been employed to synthesize cobalt oxide nanoparticles. 0.1M of cobalt chloride was added to 30ml of DI water. After that 30ml of ammonia hydroxide was mixed with 20ml of DI water. The ammonia solution was drop wise added to the transparent solution to rise the PH value 12. Then the solution was 30min of stirring and mixing. Then mixture was precipitate for 48hours. After that the precipitate was kept in oven at 90°C. The sample was finely ground into powder. Then, the sample was muffled at 500°C 2hr [7]. Finally, white powder is obtained.

3. Results and Discussion

3.1. XRD Analysis

The powder X-ray diffraction of the pure cobalt oxide nanoparticles is depicted in Fig.1. The intensity peaks observed at (111), (220) and (222) corresponding to $2\theta = 16.1778^\circ$, $2\theta = 31.8834^\circ$ and $2\theta = 39.1018^\circ$. The 2 values obtained from PXRD data of the as-prepared pure cobalt nanoparticles matched well with that of the JCPDS File No 42 - 1467. It is confirmed that the synthesized pure cobalt oxide nanoparticles exhibit a cubic structure. The sharp PXRD peaks clearly indicate the crystalline nature of the synthesized pure cobalt oxide Nano powder sample. The h k l and relative intensity values of pure cobalt oxide nanoparticles are presented.



XRD pattern of pure Co_3O_4

Position 2θ (degree)	FWHM (degree)	d-spacing (Å)	JCPDS file 2θ (degree)	(hkl)	Relative Intensity(%)
16.1778	0.3549	5.47892	5.47821	111	75.60
31.8834	0.4723	2.80688	2.80731	220	45.79
39.1018	0.4723	2.30375	2.31814	333	56.40

Table 1. Comparison of standard and observed d-spacing value

3.2. UV-Vis Absorbance Spectroscopy

To characterize the absorption properties of the synthesized samples, UV-Vis absorption spectrophotometer was used at a scan speed of 400 nm/min in the range of 200 nm to 1000 nm. The transition of electrons between the valance band, conduction band, and inherent defect levels is responsible for the peaks seen in the absorption spectra. This is Co_3O_4 distinctive absorption peak. This is explained by Co_3O_4 inherent band-gap absorption. When visible particle size increases Absorption rises. The rise in oxygen vacancies could be the cause of this. Thereafter initializing the spectrometer with a glass and plate, the sample is attached for recording. Both absorption and transmittance. The pure Co_3O_4 nanoparticles' manufactured absorbance spectra are displayed in which has a maximum peak located at 297 nm.

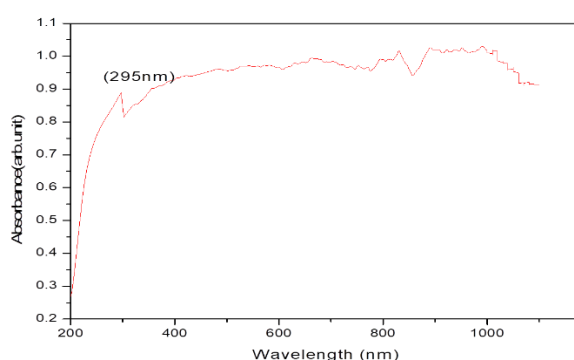


Fig.2 Optical absorbance spectra of pure Co_3O_4 nanoparticles

3.3. Fourier Transform Infrared Spectroscopy

In practical applications, FTIR investigations aid in the analysis of potential bonding between adjacent structures. The spectroscopy that studies light with a longer wavelength and lower frequency than visible light, or the infrared section of the electromagnetic spectrum, is called Fourier transform infrared Spectroscopy. In comparison to their bulk counterpart, nanoparticles have a greater surface volume to ratio (also known as aspect ratio) as more molecules or atoms are placed on the nanoparticles surface. in order to rapidly determine whether the different modes included in Co_3O_4 nanoparticles are present or not. Using dry KBr as a standard reference, infrared spectra were acquired on an FTIR spectrometer within the 4000-500 cm^{-1} range. Below 1500 cm^{-1} , metal oxide typically produces absorption bands.

FTIR analysis confirms the characteristics of nanoparticles. The observed peak wave number of the frequency group are shown in the following table. The band 3316.60 cm^{-1} corresponds to the vibration of hydroxyl group. The band at 800 cm^{-1} corresponds to the presence of cobalt oxide nanoparticles [8].

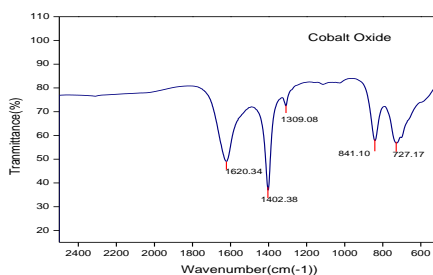


Fig 3. FTIR spectrum for as prepared Co_3O_4 nanoparticle

3.4. SEM Analysis

SEM Scanning electron microscopy (SEM) is widely used to study the size and morphology of the synthesized sample. SEM is based on a focused beam of electrons that scan the sample, which interacts with the atoms in the sample to provide three-dimensional surface topography. However, conventional SEM is performed under high vacuum and requires complex and extensive sample processing, including dehydration, fixation and metallization. SEM images of co-precipitation prepared samples are shown in figure. Nanostructures with various size and shape are obtained under different reaction parameters. It is observed that reaction temperature and duration influence morphology very much and hence the structural properties of nanoparticles. From the SEM images for synthesized at 0.1. CO_3O_4 nanoparticles are mostly in sphere shape [9].

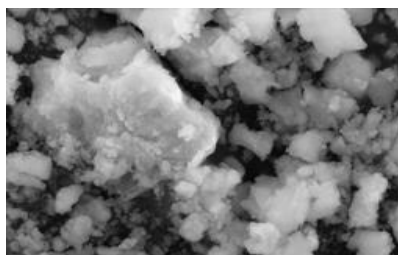


Fig.4 SEM images of ZnO particles synthesized using CO_3O_4 at concentrations of 0.1 M
Conclusion

In the present work, nanoparticles of Cobalt oxide were synthesized by a simple Co-precipitation method. The precursors used in the synthesis process were Cobalt chloride and Ammonium hydroxide. The preparation process is faster, cheaper and cost effective. The following conclusions are made from the result of this work. From the XRD characterization, it is observed that the both cobalt oxide nanoparticles belong to cubic structure. Phase identification was carried out using XRD analysis. The average particles size was calculated from the W-H plot and the Scherer's formula. The peaks that were acquired line up with standard file JCPDS file number: 42-1467. The average particle grain size, $D = 0.18888 \text{ X}$

10^{-9} nm, and the dislocation density, $\delta = 0.0002957 \times 10^{15}$ lines/m², are determined. Along the (111) plane, every particle has a preferred orientation. The absorbance of the as-prepared sample was examined using UV characterization, and it was found that the optical band GAB had an absorbance of 0.92 (arbitrary unit) with a maximum peak at 356 nm.

The optical properties of the prepared nanoparticles were analyzed using UV-Vis spectrophotometer. All the three prepared nanoparticles show lower absorbance percentage which confirms that the nanoparticles have higher transmittance. The calculated band gap proves that cobalt oxide nanoparticles are semiconductor. The fact that the nanoparticles are agglomerated to form spherical-shaped particles in the SEM analysis.

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Synthesis and Characterization with Antibacterial and Antifungal Activity Studies on some Transition Metal Complexes of N, O Donor Novel Schiff Base Ligand

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ABSTRACT

Metal complexes of Zn (II) and Mn (II) ions with Schiff base ligand derived from the condensation of Glutaraldehyde with L-alanine were prepared. The ligand and complexes were isolated from the reaction in the solid form and characterized by elemental analyses, magnetic susceptibility measurements, molar conductance data, IR, UV-Vis, ¹H-NMR spectral studies, X-ray diffraction study, SEM analysis and thermal studies. During complexation reaction with transition metal ions Schiff base act as a deprotonated bidentate ligand and IR spectra showed that N and O atoms are coordinated to the central metal atom. The observed values confirmed that the complexes have octahedral geometry. The Schiff base and its metal complexes have been found to have moderate to strong antimicrobial activity.

Keywords: Schiff base ligand, Metal complex, Spectral studies, Antimicrobial activity

1. Introduction

Schiff bases are referred to as compounds featuring an azomethine group (-HC=N-), resulting from the condensation reaction between a primary amine and an aldehyde or ketone under specific conditions [1]. These bases serve as nitrogen analogues of aldehydes or ketones, wherein the active carbonyl group (-C=O) is replaced by an imine or azomethine group. Functioning as crucial N, O donor chelating ligands [2], Schiff bases prove invaluable as chelating agents, with the potential for coordination with either the carbonyl compound, the amine, or both, especially when containing coordinating functional groups near the condensation site. Schiff bases find extensive utility across diverse domains, serving as pigments, dyes, catalysts, intermediates in organic synthesis, and even as polymer stabilizers [3]. The incorporation of metals in the form of complexes enhances their potential, contributing to antibacterial, antifungal, antitumor, anticancer, and anti-inflammatory activities [4]. In vivo investigations have revealed that certain biologically active compounds may exhibit increased carcinostatic and bacteriostatic properties through chelation [5,6]. Given the biological importance of metals, we hereby present the synthesis and

characterization of a novel Schiff base ligand derived from Glutaraldehyde and L-alanine, along with its complexes with Zn (II) and Mn (II).

2. Experimental Methods

2.1 Chemicals

Reagents such as Glutaraldehyde, L-alanine, metal (II) chloride and nitrate were of Merck products. The solvents were purified by standard methods [7].

2.2 Synthesis of Schiff base ligands

The synthesis of Schiff base ligands involved the reaction of Glutaraldehyde with L-alanine in a 1:2 molar ratio, conducted through refluxing in distilled methanol. The refluxing process extended for one hour, and the reactions were monitored intermittently using TLC until completion. Following this, the solvent was partially evaporated, resulting in yellowish mass products. These products were precipitated by cooling, filtered, washed with distilled water, dried, subjected to recrystallization, and ultimately stored in desiccators.

2.3 Synthesis of Schiff base transition metal complex

Metal (II) chloride and nitrate were dissolved in 200 cm³ of methanol. The filtrated solutions were gradually introduced drop by drop into 20 cm³ methanol solutions containing the Schiff base ligands. The resulting mixtures underwent refluxing and stirring for a duration of 8 hours. Following the reflux process, the solution volumes were reduced to one third, and the concentrates were cooled at 0°C. The formed complexes were precipitated, filtered, thoroughly washed with cold ethanol multiple times, and then dried under vacuum conditions using anhydrous CaCl₂.

3. Results and Discussion

3.1. Physical Properties and Elemental Analyses:

The physical properties and results obtained from C.H.N. analyses and metal contents of the prepared compounds are presented in **Table 1**. The metal complexes were formed in 1:1 stoichiometric ratio and were normally stable at room temperature and hygroscopic in nature. The Schiff base ligands formed were soluble in common organic solvents like ethanol and methanol. The corresponding complexes were soluble in DMSO. The Zn (II) and Mn (II) complexes were non-electrolytic in nature.

Table 1 Analytical and physiochemical data of Schiff bases and its metal complex

Ligand/ Metal Chelate	Empirical Formula	Colour	M:L ratio	Molar Cond. (Ohm^{-1} $\text{cm}^2 \text{mol}^{-1}$)	Elemental analysis % Found (calculated)			
					C	H	N	M
HGlu(ala) ₂	C ₁₁ H ₂₂ N ₂ O ₆	Yellow	-	-	67.89 (65.78)	9.6 (8.8)	8.6 (9.3)	-
ZnGlu(ala) ₂ .2H ₂ O	C ₁₁ H ₂₂ N ₂ O ₆ Zn	Pale Yellow	1:1	0.062	51.89 (52.68)	6.29 (6.49)	7.98 (8.19)	17.98 (18.58)
MnGlu(ala) 2.2H ₂ O	C ₁₁ H ₂₂ N ₂ O ₆ Mn	Brown	1:1	0.071	53.67 (52.99)	6.98 (6.80)	7.65 (8.10)	17.55 (18.06)

3.2 UV-Visible Spectra

UV-Visible spectra are valuable for assessing structural information complementing other investigative methods [8]. In the electronic spectrum of Schiff base ligands', intense bands at 275 nm and 280 nm indicated the $\pi - \pi^*$ transition of the C=N chromophore. Complexation resulted in a shift to lower wavelengths at 235 nm and 250 nm, signifying the coordination of azomethine nitrogen with metal ions. Additional transitions at 337 nm and 348 nm were attributed to $n - \pi^*$ transitions. Notably, weak bands at 400-500 nm in the UV-Vis spectra represented charge transfer bands unique to the complex, absent in the ligands. Meanwhile, weak broad bands at 500-600 nm were indicative of d-d transitions specific to the Mn (II) ion. Electronic and magnetic moment values provided insights into the geometry of the newly synthesized metal complexes.

Magnetic susceptibility measurements are instrumental in anticipating the metal complex's potential geometry [9]. For the Mn (II) complex, the octahedral geometry is characterized by a magnetic moment of 5.97 BM, configurations of d^5 stereochemistry as octahedral, hybrid orbitals as sp^3d^2 , 5 unpaired electrons, and an anticipated value of 6.00 BM. The magnetic moment value offers crucial insights into the complex's composition and structure, falling within the anticipated range for octahedral complexes. Notably, Zn (II) complex lack d-d transitions in their electronic spectra and exhibit the expected diamagnetic behavior.

3.3 Infrared spectra

Infrared spectra (IR) play a crucial role in discerning coordination sites, especially in Schiff base complexes with multidentate ligands. These spectra offer valuable insights into the nature of functional groups attached to the metal ion [10]. By comparing the IR spectra of

the complexes with those of the free Schiff base ligand, we can identify the coordination sites involved in the chelation process. The ligands' IR spectra reveal a broad band in the 3200-3500 cm^{-1} range, indicative of intramolecular hydrogen-bonded -OH groups. The presence of this peak in the complex spectra suggests the involvement of -OH groups in the complexation process. The spectrum of the ligands showed $\text{C}=\text{N}$ band in the region of 1654 - 1660 cm^{-1} which was shifted to lower frequency in the spectra of the corresponding metal complex indicating the involvement of $\text{C}=\text{N}$ nitrogen in coordination to the metal ions. Accordingly, the ligands act as a tetradentate chelating agent, bonded to the metal ion through the four nitrogen atoms of the Schiff base. Assignment of the proposed coordination sites were further supported by their appearance of medium bands at 550 - 450 cm^{-1} which could be attributed to M-N respectively. In addition, the metal complexes showed bands at 565 - 575 cm^{-1} that was attributed to M-O frequency. The IR spectra of the synthesized Schiff base complexes are given in Fig 1 and 2.

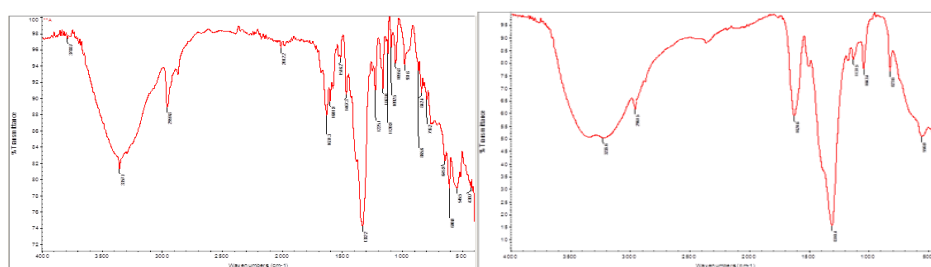


Fig 1and 2: IR Spectra of $\text{ZnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ and $\text{MnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ Schiff base complexes

3.4 ^1H NMR Spectra

The ^1H NMR spectrum of the ligand H Glu(ala)₂ recorded in DMSO solution shows a multiplet at 2.5, 2.3, 1.6 and 1.8 ppm due to the methyl protons. Further more, the ^1H NMR Spectrum of the Schiff base complexes $\text{ZnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ and $\text{MnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ exhibited signals at 8.4 ,8.8, 8.1, 8.7 ppm and 7.8 , 7.9, 7.5, 7.4 ppm, that is attributable to $\text{CH}=\text{N}$ - and $-\text{NH}$ protons respectively. The azomethine proton signal in the spectrum of the corresponding complexes are shifted downfield compared to the free ligands, suggesting the deshielding of the azomethine group due to the coordination with the metal ions. There are no appreciable change in all other signals of the complexes.

3.5 Powder XRD Study

The powder XRD shows that $\text{ZnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ and $\text{MnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ complexes has the crystallite size of 41 nm and 46 nm suggesting the microcrystalline nature. The powder XRD pattern of the M(II) Schiff base complexes are given in Fig 3 and 4.

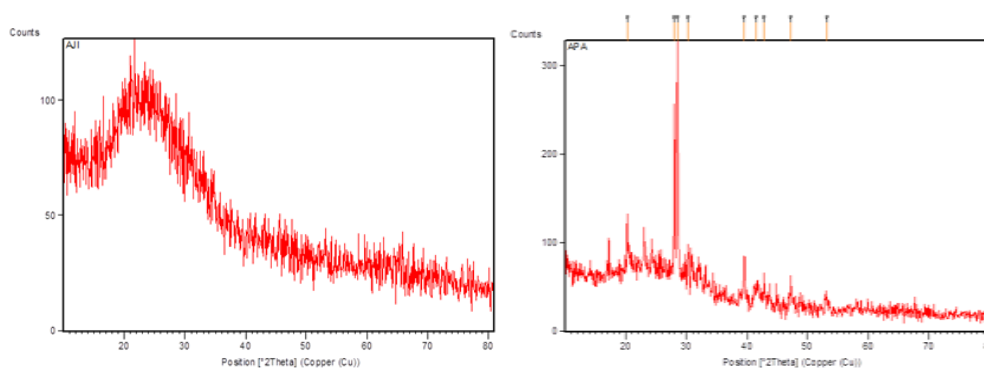


Fig. 3 and 4: Powder XRD pattern of the $\text{ZnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ and $\text{MnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ complexes

3.6 Scanning Electron Microscope

Scanning electron micrographs provided insights into the morphology of Schiff base ligands and their respective metal complexes. Captured at 20 kV accelerating voltage, magnification ranged from 150x to 1000x. Notably, macroscopic phase separation in the dense layer was evident, featuring void spaces with a domain size of about 100 μm across all systems, a consequence of macroscopic phase separation [11]. The ligands exhibited a spongy and soft surface with pronounced phase separation, which diminished upon complex formation. Introduction of metal ions further reduced sponginess and softness, aligning with previous observations on decreased phase separation and surface softness upon complexation [12]. SEM images underscored a notable change in the Schiff base's morphology upon complexation, as depicted in Fig.5 and 6.

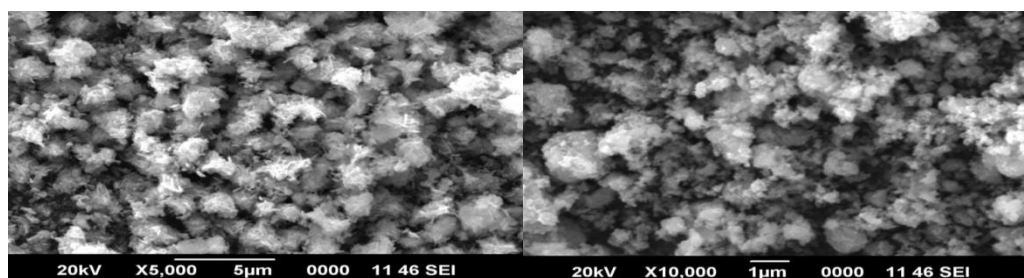


Fig.5 and 6: SEM images of $\text{ZnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ and $\text{MnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ complexes

3.7 Thermal analysis

In this study, thermogravimetric analysis (TG) and differential thermal analysis (DTA) were employed. TG analyses of Zn(II) and Mn(II) complexes were conducted from room temperature to 900°C, displaying a consistent pattern with comparable calculated and experimental mass losses. The weight loss between 117–207°C, representing the loss of two coordinated water molecules, showed an experimental mass loss of 2.35–2.55% across the complexes, aligning with the calculated value of 2.86%. This temperature range for water

loss indicates strong bonding between water molecules and the metal ion, a characteristic thermal behavior of coordinated water molecules [13]. From 197°C to 463°C, a significant weight decrease indicated the loss of fragments from two Schiff base molecules in the complexes, with experimental mass losses of 46.32-48.32%. In the final stage (453-605°C), both decomposition products and a black residue were eliminated, with experimental mass losses of 31.75–32.75% for the complexes. Chemical analysis of the black residue confirmed the presence of metallic oxide. In summary, TG experiments provided insights into the anhydrous nature of complex species, validating their compositions suggested by analytical data.

3.8. Antimicrobial Study

Qualitative assessment of susceptibility spectra for various microbial strains to newly synthesized compounds revealed significant antimicrobial effects, evidenced by the presence of a growth inhibition zone (Table 2). All tested compounds demonstrated superior antimicrobial activity, as indicated by larger inhibition zones compared to DMSO alone and the ligand. Notably, the $\text{MnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ complex exhibited the lowest antimicrobial spectrum, while the $\text{ZnGlu(ala)}_2 \cdot 2\text{H}_2\text{O}$ complex displayed the largest inhibition zones, proving effective against all tested microbial strains. Tweedy's chelation theory [14] provides insight into the enhanced antimicrobial activity of the metal complexes.

Table 2 Antimicrobial activities of Schiff base ligands and its complexes by disc diffusion method (Zone inhibition in mm)

Compound	Microbial Species					
	<i>E.coli</i>	<i>S.aureus</i>	<i>Kleb.sps</i>	<i>A.niger</i>	<i>A.fumigates</i>	<i>Candi.sps</i>
Control	24	22	25	20	20	30
HClu(ala) ₂	5	6	3.5	2.5	4.5	5
ZnGlu(ala) ₂ ·2H ₂ O	13.6	17.9	15.9	14	15.5	18
MnGlu(ala) ₂ ·2H ₂ O	10	9	8.5	9.5	10.5	9

Based on the spectral and analytical data, the structure of the synthesized compounds Where M is Zn or Mn are given below.

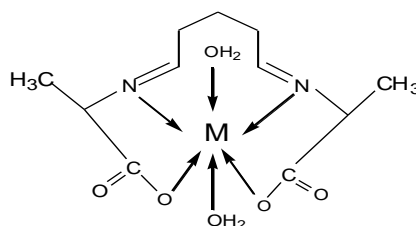


Fig 8. Structure of HGlu(ala)₂ complexes

4. Conclusion

The metal (II) complexes synthesized from the Schiff base derived from the condensation of Glutaraldehyde with L-alanine were characterized by different physico-chemical and spectral methods. IR spectra analysis revealed the ligand's bidentate coordination in the complexes. Electronic spectra and magnetic measurements suggested an octahedral geometry for Mn (II) and Zn (II) complexes. Biological activity results indicated that the newly synthesized complexes exhibited enhanced antimicrobial activity against bacteria and fungi compared to both the ligand and the included antibiotic. These findings suggest the potential use of these complexes in the development of novel antimicrobial materials.

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Green Synthesis, Characterization and Antimicrobial Activity of Cobalt Oxide NPs Obtained using *Cassia occidentalis* Plant Extract

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ABSTRACT

Cobalt oxide Nanoparticles (NPs) find applications in the synthesis of lithium-ion batteries, pigments and dyes, electronic thin film, capacitors, gas sensors and heterogeneous catalysis. Hence, they are synthesised on a large scale. However, the synthesis using chemical methods pollute the environment and leads to environmental degradation. Green synthesis of cobalt oxide NPs using medicinal plant extracts are environmental friendly, cheaper and involves only less number of steps. Ethanolic extracts of Cassia occidentalis leaves are used as green reducing agents for synthesising cobalt oxide NPs from cobalt chloride salt. The FT-IR spectrum proved the formation of cobalt oxide NPs. XRD patterns showed that the NPs synthesised are crystalline and cubic in nature. Antibacterial activity was studied by disc diffusion method using standard amikacin against S.aureus and P.aeruginosa. The results proved that the NPs produced possess good antibacterial activity.

Keywords: Anti-inflammatory, *Cassia occidentalis* (*C. occidentalis*), detoxify, hepatoprotective, XRD.

1. Introduction

NPs possess varied applications in human life. Hence, they are synthesised enormously. Different methods are available in the literature for the synthesis of NPs but, other than green methods, all are expensive and liberates large amount of toxic pollutants leading to environmental pollution. Diverse types of NPs can be synthesised using green technology. The reactions are carried out in one step. Similarly, chemical methods are used to synthesize NPs by electro deposition, sol-gel process, chemical solution deposition, chemical vapour deposition soft chemical method, Langmuir Blodgett method, catalytic route, hydrolysis co-precipitation method and wet chemical method. Chemical and physical methods use high radiation, highly concentrated reductants and stabilizing agents that are harmful for the environment and human health. Hence, biological synthesis of NPs is a single step bio-reduction method and less energy is used to synthesize in an eco-friendly way. In general, green nano-biotechnology means synthesizing NPs using biological routes such as those involving microorganisms, plants, and viruses or their byproducts, such as proteins and lipids, with the help of various biotechnological tools. For example, green techniques

eliminate the use of expensive chemicals, consume less energy, and generate environmentally benign products and by products [1].

C. occidentalis is a medicinal plant widely distributed in Kanyakumari district. It has antibacterial, antidiabetic, anti-inflammatory, anti-cancerous, anti-mutagenic, hepatoprotective activity. It also plays a major role as a green reducing agent. Hence it is selected as a source for green reducing agent.

2. Materials and methods

2.1 Materials

C. occidentalis plant leaves were collected from Kurusady Village, Nagercoil, Kanyakumari District. Ethyl alcohol and analar Cobalt (II) chloride hexa hydrate were purchased from Merck, India. Deionised water was used in the entire study.



Fig.1. *C. occidentalis*

Table .1 Details of plants selected for the study

Plant	<i>Cassia occidentalis</i>
Classification	Kingdom: Plantae Order: Fabales Family: Fabaceae
Origin	Tropical and subtropical regions of America
Cultivation	Asia, Africa, North and Central America and Caribbean
Phytochemicals	Phlobatannins, anthroquinone, saponins, terpenes, resins, balsams, amino acids and cardiac glycosides [2] Achrosin, aloe-emodin, emodin, anthrones, apigenin, apigenin, quercetin, rhamnosides, rhein and rubrofusarin [3]
Medicinal uses	Leprosy & diabetes [4] laxative & purgative, inflammation and rheumatism, liver diseases [6] haematuria, rheumatism, typhoid, asthma and disorders of haemoglobin [7].

2.2 Preparation of plant extract

The leaves of *C. occidentalis* were collected in the month of November. Fresh and healthy plants free from contaminants were collected, washed thoroughly in water, allowed to drain and shade dried for 15 days. Only the leaves of the plant were used for the study. The dried leaves were powdered and extracted using Soxhlet extractor using ethyl alcohol as the solvent. The chemical composition of the extracts was analysed using FT-IR spectroscopy.

2.3 Synthesis of metal oxide NPs

The cobalt oxide NPs required for the study was reduced to nanosized cobalt oxide particles from cobalt chloride salts by using the ethanolic extract of *C. occidentalis* as green reducing agent.

20g of analar Cobalt (II) chloride hexa hydrate was mixed with 10 mL of *C. occidentalis* extract. The resulting solution was heated to 80°C with continuous stirring using a magnetic stirrer for one hour and thirty minutes [8]. The formation of cobalt oxide NPs was indicated by a grey colour. The cobalt oxide NPs formed were centrifuged and dried, calcined at 800°C in a muffle furnace and packed in an air tight container.

2.4 Antibacterial assay

In vitro antibacterial assay was carried out by standard disc diffusion technique [9]. Whatman No.1 filter paper discs (6 mm diameter) were impregnated separately with ethanolic extracts of plant leaves and metal oxide NPs. The impregnated discs were placed in Muller Hinton agar plates seeded with test bacterial cultures. A positive control of a standard antibiotic (Amikacin) disc and also sterile disc as a negative control were placed on the same plate. After incubation at 37°C for 24 hours, antibacterial activity was determined based on the diameter of the zone of inhibition.

3. Results and discussion

3.1 FT-IR spectrum of *C. occidentalis*

The FT-IR spectrum of ethanolic extract of *C. occidentalis* (Fig.2) showed a strong broad stretching band at 3320 cm^{-1} which may be ascertained to the stretching of H-bonded -OH of alcohol. The strong stretching bands observed at 2975 cm^{-1} and 2881 cm^{-1} may be due to C-H stretching. Stretching observed at 1651 cm^{-1} may be due to C=C of alkene. The band at 1377 cm^{-1} may be due to -C-H bending of alkane. CN stretching of amine was observed at 1326 cm^{-1} and 1081 cm^{-1} . The strong band at 1045 cm^{-1} may be due to C-F stretching of alkyl halide. The strong band at 881 cm^{-1} may be due to C-Cl stretching. Strong C-H bending of alkene was observed at 621 cm^{-1} . Similar results for FT-IR spectrum of *C. occidentalis* reported in the literature [10].

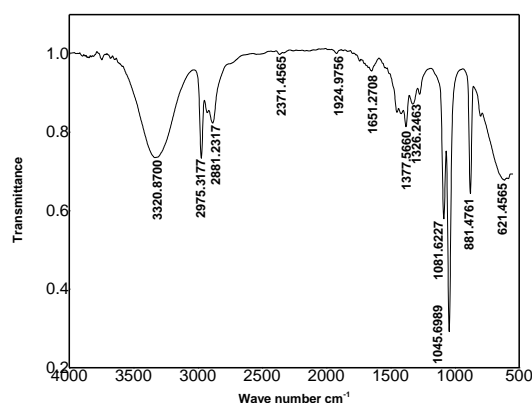


Fig. 2. FT-IR spectrum of *C. occidentalis* ethanolic extract

The FT-IR absorption frequencies and the functional groups identified are given in **Table 2**.

Table 2. FT-IR absorption frequencies of *C. occidentalis* ethanolic extract

Plant extract	Absorption range	Functional groups
<i>C. occidentalis</i>	3320	Strong, broad – stretching of H- bonded O-H bond
	2975, 2881	Strong stretching of C-H bond
	1651	C=C stretching of alkene
	1377	-C-H bending of alkane
	1326, 1081	-CN stretching of amine
	1045	Strong, C-F stretching of alkyl halide
	881	Strong, C-Cl stretching
	621	Strong, =C-H bending of alkene

3.2 FT-IR spectrum of cobalt oxide NPs *C. occidentalis* from extract

Table 3. shows the absorption frequencies and the responsible functional groups identified in the ethanolic extract of *C. occidentalis*.

Table 3. FT-IR absorption frequencies of cobalt oxide NPs from *C. occidentalis* ethanolic extract

Wave number (cm ⁻¹)	Responsible group
3696, 3680, 3647, 3608, 3589, 3556	Sharp strong -OH stretching of free -OH of alcohol
3354, 3230	Strong broad band stretching of H-bonded alcoholic -OH or NH of amide or amine

2960, 2924	Strong stretching of -CH of alkane
1793, 1767, 1738	Strong stretching of C=O group of carbonyl
1705	Strong CO stretching of acid
1533, 1510, 1464, 1421	Multiple bands aromatic C=C stretching
1366	Bending of C-H of alkane
1340, 1311, 1240, 1171	Medium -CN stretching
944	Band =C-H bending of alkene
754, 710	Strong band -CCl stretching of alkyl halide
672, 577	Stretching vibrations in Co^{2+}

3.3 XRD of cobalt oxide NPs from *C. occidentalis*

The XRD pattern of cobalt oxide NPs synthesised using the ethanolic extract of *C. occidentalis* (Fig.3) does not show very sharp diffraction peaks. Few peaks corresponding to 2θ values 16.04° (101), 18.45° (110), 20.86° (110), 25.39° (111), 30.54° (111), 33.16° (101), 35.07° (101), 37.98° (110), 41.05° (110) and 43.80° (101) were observed. The crystal possessed Co_3O_4 lattice with cubic structure according to JCPDS file no. 65-3103. Using debye-Scherrer equation, the crystalline size of the NPs was found to be 73.14 nm. XRD pattern suggested that the cobalt oxide NPs synthesised were not well crystalline.

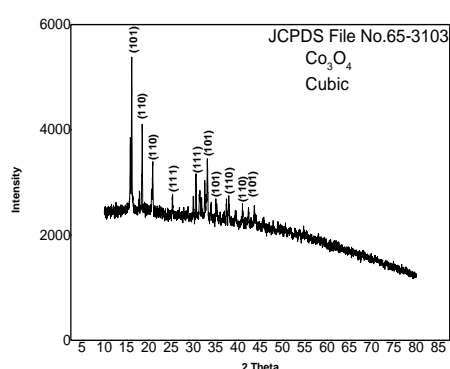


Fig. 3. XRD of cobalt oxide NPs from *C. occidentalis*

3.4 Antibacterial assay

The zones of inhibition produced by *C. occidentalis* and cobalt oxide NPs are given below.

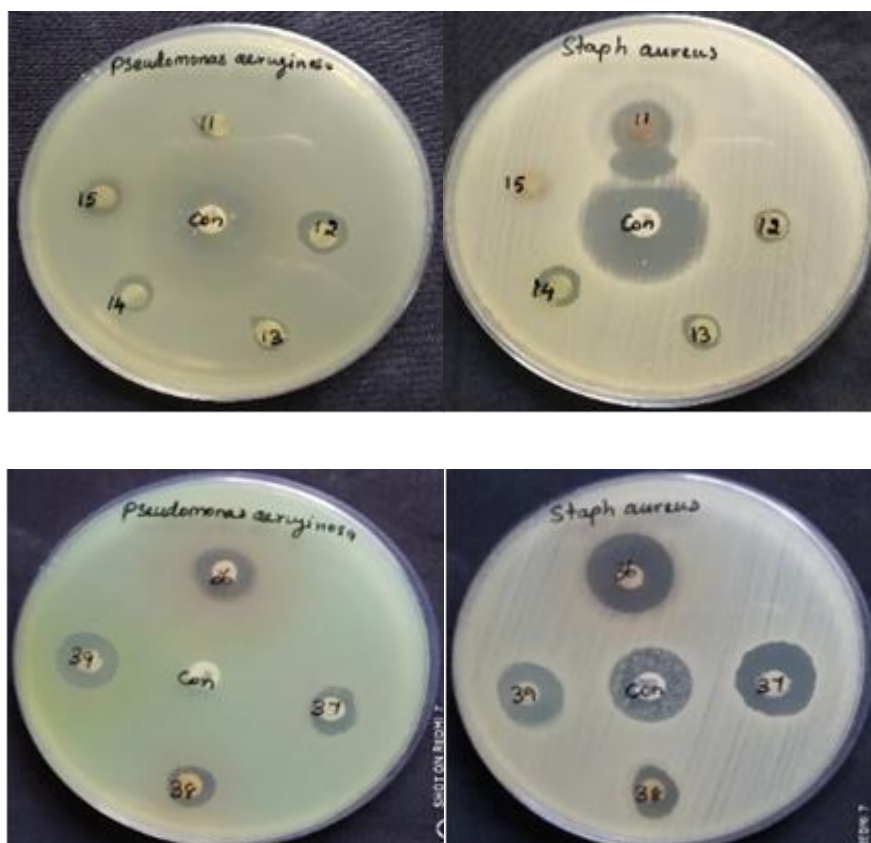


Fig.4. Zones of inhibition 11- *C. occidentalis* 36 - cobalt oxide NPs

Table 4. Zone of inhibition

Extract / metal oxide	Zone of inhibition (mm)			
	<i>P. aeruginosa</i>	Control Amikacin	<i>S. aureus</i>	Control Amikacin
<i>C. occidentalis</i>	9	20	15	13
Nano cobalt oxide	25	-	28	19

P. aeruginosa was treated against *C. occidentalis*. The zone of inhibition observed was 9mm whereas the control showed 20 mm inhibition. The antibacterial activity against *S. aureus* was greater than the control. Hence it is very effective against *S. aureus*. Nano cobalt oxide NPs is found to have very good antibacterial activity against both *P. aeruginosa* and *S. aureus*.

4. Conclusion

C. occidentalis ethanolic extract act as a good green reducing agent in the synthesis of cobalt oxide NPs. The cobalt oxide NPs are found to be in cubic crystal system. Both *C.*

occidentalis and Nano cobalt oxide NPs show good antibacterial activity against both *P. aeruginosa* and *S. aureus*.

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Evaluation of Antioxidant and Antidiabetic Potentials of Aldimine Synthesized from Vanillin and Aniline using *Malpighia emarginata* Fruit Extract

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ABSTRACT

*Aldimines are compounds containing azomethine group ($-HC=N$) and it represents a category of molecules crucial in pharmaceuticals and medicine. Traditional approaches for the synthesis of aldimines require extended reaction durations and employment of organic solvents. The aim of the present study is to analyse the antioxidant and antidiabetic potentials of aldimines synthesised from vanillin and aniline using *Malpighia Emarginata* fruit extract. The aldimine synthesised from *Malpighia Emarginata* fruit extract is characterized by UV-Visible and FT-IR spectral techniques. The antioxidant activity of synthesised aldimines is determined using 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay method and the IC_{50} value is found to be 769.23 $\mu\text{g/mL}$. The in vitro antidiabetic activity of the synthesised aldimine is determined by alpha glucosidase inhibition assay method and the IC_{50} value is found to be 205.36 $\mu\text{g/mL}$. The obtained results revealed that the synthesised aldimine shows slight antioxidant and antidiabetic activity. Thus, the biological activities of the synthesised aldimines will trigger more interest in the synthesis of these types of compounds from the easily available starting materials.*

Keywords: Solvent-free synthesis, *Malpighia emarginata* extract, Aldimine, Antioxidant activity, Antidiabetic activity

1. Introduction

Green Chemistry also known as sustainable chemistry, is the branch of chemistry that deals with the design and optimization of processes and products in order to lower, or remove altogether the production and use of toxic substances. This technique involves as an alternative reaction media to replace hazardous and expensive solvents routinely used in organic synthesis [1]. Organic reactions under solvent-free conditions have gained popularity in recent years, since the majority of solvents are either toxic or flammable and add considerably to the cost of an overall synthesis. Solvent-free conditions can be applied to various organic reactions, including condensation, cyclization, oxidation, and reduction reactions, showcasing versatility across different chemical transformations. These solvent-free reactions usually need shorter reaction time, simpler and more efficient work up

procedures, more improved selectivity's and easier separations and purifications than conventional solvents [2].

Aldimines are important intermediates for the synthesis of various bioactive products and they are used as fundamental materials for the synthesis of various Schiff base ligands which are used as chiral auxiliaries in asymmetric synthesis [3]. Aldimines have been reported to show a variety of biological actions by virtue of the azomethine linkage, which is responsible for various antibacterial, antifungal, herbicidal and clinical activities [4,5]. The conventional methods for the synthesis of aldimines produce hazardous waste, took long time and produce very low yield [6]. Therefore, modification of synthetic method using green techniques *viz* solvent-free approach and grindstone methods are used to maximize the yield production [7]. Recently fruit juice is known to be a potential organic solvent for the synthesis of compounds of pharmaceutical interest [8]. Fruit juice is being used on regular basis in various organic transformation reactions [9]. The widespread applications of different fruit juices are due to their non-toxic, safe, inexpensive and environmentally benign nature. Bioactive compounds like enzymes, polyphenols, vitamins, and carotenoids can be extracted from fruit and vegetables waste and are potentially utilized for the synthesis of organic compound [10].

Based on the literature survey, the present work focusses on the solvent free synthesis of aldimine from vanillin and aniline using *Malpighia emarginata* fruit extract. The *Malpighia emarginata* fruits are rich in vitamin C, carotenes, thiamine, riboflavin, niacin, proteins and mineral salts, mainly iron, calcium and phosphorous [11]. The *Malpighia emarginata* fruit is one of the best natural sources of vitamin C than other fruits like guava, cashew, orange, and lemon [12]. The fruits are considered as beneficial against liver problems, diarrhoea, dysentery, cough and cold. The aldimine synthesised from *Malpighia emarginata* fruit extract is characterized by UV-Visible and FT-IR spectral techniques. The synthesised aldimine shows slight antioxidant and antidiabetic activities.

2. Materials and Methods

Fresh and ripened *Malpighia emarginata* fruit were collected from the college campus. Vanillin and aniline used for the synthesis of aldimine were procured from Merck. Double-distilled deionized water was used for the preparation of the *Malpighia emarginata* fruit extract. Analytically graded ethanol was used for the recrystallisation of the synthesized product.

2.1. Preparation of *Malpighia emarginata* extract

Fresh and ripened *Malpighia emarginata* fruit was used for the preparation of the extract. 25 g of fresh ripened fruit was taken and washed thoroughly with double-distilled deionized water. The fruit was grinded using pestle and mortar. The resulting extract was filtered using Whatman filter paper and the filtrate was collected and then centrifuged for about 8000 rpm for about 10 minutes. The supernatant extract was collected and used for the synthesis of aldimine.

2.2 Synthesis of aldimine from *Malpighia emarginata* extract

Equimolar amount of vanillin (0.1 mol) and aniline (0.1 mol) were taken in a clean beaker. About 2 mL of *Malpighia emarginata* extract was added to the mixture and stirred well at room temperature. The pale-yellow precipitate was formed immediately after the addition of the fruit extract. The corresponding aldimine obtained was washed well with distilled water and purified with minimum amount of ethanol (**Scheme 1**).



Scheme 1 Synthesis of aldimine from vanillin and aniline

2.3 Characterization Techniques

The absorption spectral measurement of the synthesised aldimine was carried out using Shimadzu UV-1800 spectrophotometer. FT-IR analysis of the synthesised compound was carried out through the potassium bromide (KBr) pellet (FTIR grade) method in 1:100 ratio and the spectrum were recorded using Shimadzu IR Affinity.

2.4 Antioxidant activity

The antioxidant activity of the synthesised aldimine was determined by 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay method. For DPPH assay the ascorbic acid was used as reference standard. The ascorbic acid stock solution was prepared in distilled water (1 mg/mL; w/v). 60 μ M solution of DPPH in methanol was freshly prepared and 200 μ L of this solution was mixed with 50 μ L of test sample at various concentrations (1.56, 3.12, 6.25, 12.5, 25, 50, 100, 200, 400, 800 and 1000 μ g/mL). The plates were kept in the dark for 15 min at room temperature and the decrease in absorbance was measured at 515 nm. Control was prepared with DPPH solution only, without any extract or ascorbic acid. 95% methanol was used as blank.

$$\% \text{ of Inhibition} = [(\text{Abs of control} - \text{Abs of test}) / \text{Abs of control}] \times 100$$

The IC₅₀ value was determined from the plot of percentage inhibition *versus* log inhibitor concentration and calculated by non-linear regression analysis from the mean inhibitory values.

2.5 Antidiabetic Activity

The antidiabetic activity of the synthesised aldimine was determined using alpha glucosidase inhibition assay method. About 400 µL of α-glucosidase (0.067 U/mL) was preincubated with different concentrations of the aldimine for 30 min. Then 200 µL of 3.0 mM *p*-nitrophenyl glucopyranoside (pNPG) used as substrate dissolved in 0.1 M sodium phosphate buffer (pH 6.9) was then added to start the reaction. The reaction mixture was incubated at 37°C for 30 min and stopped by adding 2 mL of 0.1 M Na₂CO₃. The alpha glucosidase activity was determined by measuring the yellow-coloured *p*-nitro phenol released from pNPG at 400 nm. The results were expressed as percentage of inhibition. Same procedure was done with acarbose (1 mg/mL stock) which was used as standard.

$$\text{Inhibitory activity (\%)} = (\text{B-T/B-C}) \times 100$$

Where, B is the absorbance of blank. T is the absorbance in the presence of test substance. C is the absorbance of control.

3. Results and Discussion

The role of *Malpighia emarginata* extract in the synthesis of biologically active aldimine from vanillin and aniline is reported in this section. The synthesised aldimine is characterized by UV-Visible and FT-IR spectral analysis. This solvent-free approach is non-polluting and does not employ any toxic materials, quantifying it as a green approach for the synthesis of aldimines.

3.1 Absorption Spectral Analysis

The formation of aldimine from vanillin and aniline using *Malpighia emarginata* extract is preliminary confirmed by UV-Visible spectrophotometric analysis. The aldimine synthesised from vanillin and aniline shows absorption bands at 220, 232, 278 and 325 nm due to π - π^* and n - π^* transitions (Fig. 1). The higher energy band appearing at 278 nm is attributed to π - π^* transition of the azomethine group [13]. Thus, the absorption spectral data confirms the formation of aldimine from vanillin and aniline.

3.2 FT-IR Spectral Analysis

The FT-IR spectrum of aldimine synthesised from vanillin and aniline using *Malpighia emarginata* extract shows absorption bands 3526, 2924, 2853, 2742, 1674, 1587, 1288, 970, 923, 872, 816, 769, 714, 614 and 520 cm⁻¹ respectively (Fig. 2). The band at 3526 cm⁻¹ is due to O-H stretching of the hydroxyl group. The weak bands at 2924, 2853 and 2742

cm^{-1} are due to the C-H stretching of alkenes and aromatic system. The band at 1674 cm^{-1} is due to the presence of azomethine group, this indicates the formation of aldimine. The weak band at 1587 cm^{-1} is due to the stretching vibration of aromatic C=C bond. The band at 1288 is due to C-O cm^{-1} stretching vibration of methoxy group. Aromatic C=C and aliphatic C-H bending vibrations occur at 970, 923, 872, 816, 769, 714, 614 and 520 cm^{-1} respectively. The FT-IR spectral data thus confirms the formation of aldimine from vanillin and aniline.

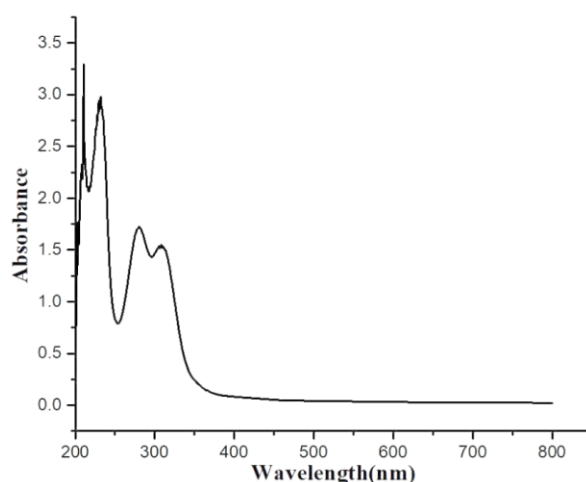


Fig.1 Absorption spectrum of aldimine from vanillin and aniline

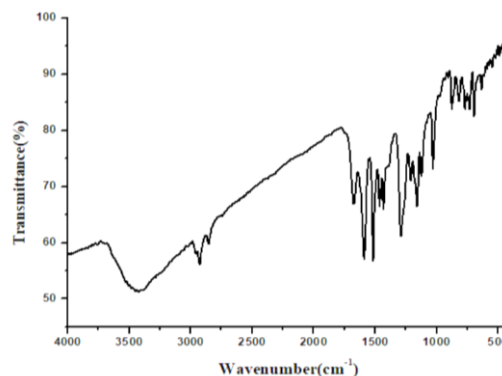


Fig. 2 FT-IR spectrum of aldimine synthesised from vanillin and aniline

3.3 Antioxidant activity of Aldimine

The antioxidant activity of the synthesised aldimine at different concentrations are determined and tabulated in **Table 1**. The synthesized aldimines produce low free radical scavenging at all concentration ranges compared to ascorbic acid. The IC_{50} value of aldimine synthesised from vanillin and aniline is $769.23 \mu\text{g/mL}$. The antioxidant potential measured by DPPH free radical inhibition assay method reveals that the synthesised aldimine shows slight activity than that of ascorbic acid. The antioxidant activity is stoichiometric with respect to the number of hydrogen atoms absorbed. In the present investigation, the synthesised aldimine donate only one proton for the stabilization of the DPPH free radical, while ascorbic

acid has ability to donate its two protons to the DPPH radical to form a neutral compound, dehydroascorbate [14]. Thus, the aldimine synthesised from vanillin and aniline shows slight antioxidant activity and can be used as free radical scavenger.

3.4 Antidiabetic activity of Aldimine

The antidiabetic activity of the aldimine synthesised from vanillin and aniline at different concentrations are determined and tabulated in **Table 2**. The synthesised aldimine shows higher IC₅₀ value, 205.36 µg/mL than that of the standard acarbose. Lower IC₅₀ value reflects better antidiabetic activity. The synthesized aldimine produce lower antidiabetic activity as compared to that of acarbose. Thus, the obtained results revealed that the aldimine synthesised from vanillin and aniline show slight antidiabetic activity.

Table 1 Antioxidant activity of aldimine synthesised from vanillin and aniline

Concentration (µg/mL)	Absorbance at 515 nm	% of Inhibition
0	0.8726	0
1.56	0.8467	2.97
3.12	0.8023	8.06
6.25	0.7525	13.77
12.5	0.6936	20.51
25	0.6475	25.80
50	0.6205	28.89
100	0.5695	34.74
200	0.5406	38.04
400	0.4905	43.79
800	0.4325	50.43
1000	0.4018	53.96
IC ₅₀	769.23 µg/mL	

Table 2 Antidiabetic activity of aldimine synthesised from vanillin and aniline

Concentration (µg/mL)	Absorbance at 400 nm	% of Inhibition
1.5	1.751	2.33
3.125	1.652	7.96
6.25	1.597	11.09

12.5	1.518	15.59
25	1.362	24.46
50	1.302	27.87
100	1.202	33.56
IC₅₀	205.36 µg/mL	

Conclusion

An eco-friendly route for the synthesis of aldimine from vanillin and aniline using *Malpighia emarginata* extract has been investigated. The aldimine synthesised from the *Malpighia emarginata* extract is characterized by UV-Visible and FT-IR spectral analysis techniques. The aldimine shows an absorption maximum at 278 nm, due to $\pi - \pi^*$ transition of azomethine group. The FT-IR band at 1674cm^{-1} is due to the presence of azomethine group, this confirms the formation of aldimine. The antioxidant and antidiabetic activities of the synthesised aldimine show slight activity than that of the control. This solvent-free approach is non-polluting and does not employ any toxic materials, quantifying it as a green approach for the synthesis of aldimines. The biological activity of this compound will trigger more interest in the synthesis of such compounds from the easily available starting materials.

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***Cocos nucifera* Husk-Based Silver Nanoparticles for Antimicrobial Studies**

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ABSTRACT

*Nanoparticles and nanomaterials can be prepared by bio-nanotechnology approaches because they are economical and ecologically benign. The potential of the plant extract from *Cocos nucifera*, to produce silver nanoparticles (Ag NPs) is confirmed by this work. The presence of surface plasmon resonance at 290 nm confirmed the formation of silver nanoparticles (Ag NPs). The crystalline nature of the nanoparticles was confirmed using XRD studies. Scanning electron microscopy (SEM) pictures showed that the particles has almost spherical form. Potential biomolecules accountable for the bio-reduction of silver ions are found by Fourier-transform infrared (FTIR) spectroscopy. The biosynthesized Ag NPs' microbial efficacy against Gram-positive, Gram-negative and fungal species is confirmed by an antimicrobial assay.*

Keywords: *Green synthesis, Crystal violet, Organic dye, Antibacterial activity, Antifungal activity*

1. Introduction

Green chemistry approach to nanomaterials and nanoparticles preparation is an eco-friendly, cost effective, and inexpensive method which employs environmentally benign materials, biodegradable, non-toxic, and natural substances. Recently, studies on the application of metal nanoparticles (particles with <100 nm) to fabrics are emerging rapidly and gaining research interest [1-4] due to their high surface to volume ratio size dependent properties and excellent biological activities as compared to bulk scale. Silver nanoparticles have been recognized by several researchers due to their low toxicity to normal cells, broad range of antimicrobial properties, and breakdown of organic dyes [1, 5]. The antimicrobial properties of silver nanoparticles depend on their nanoscale dimension [6]. Silver nanoparticles can be synthesized using the green chemistry method employing plant extracts [7,8]. Furthermore, the study investigates the multifaceted applications of these green-synthesized AgNPs using *Cocos nucifera* fiber extract. Their efficacy in dye degradation is explored, showcasing their potential as catalysts for the removal of organic dyes from aqueous solutions. The degradation process is monitored using various analytical techniques,

shedding light on the efficiency and kinetics of the AgNPs-mediated degradation. Additionally, the antimicrobial activity of the synthesized AgNPs is evaluated against a spectrum of pathogenic microorganisms. The antimicrobial potential is assessed through well-established methods, providing insights into the AgNPs' effectiveness in inhibiting the growth of bacteria and fungi. This comprehensive study aims to contribute valuable insights into the green synthesis of AgNPs, their thorough characterization, and their diverse applications in environmental remediation and healthcare. The results presented underscore the potential of these green-synthesized AgNPs as multifunctional nanomaterials with promising prospects for sustainable and effective applications in various fields.

2. Materials and methods

2.1 Materials

Analytical grade of Silver Nitrate and Crystal violet were purchased from Merck. The solvents used were of analytical grade.

2.2 Experimental method

0.1M Silver nitrate solution was prepared by taking 3.39g of silver nitrate and making up to 200mL in a Standard Measuring Flask and was stored in the dark to prevent photodecomposition reaction. For further synthesis of silver oxide nanoparticle about 100mL of the above made-up solution is taken in a 250mL beaker and add 20mL of *Cocos nucifera* extract to this in dropwise. The mixture is shaken in a magnetic stirrer for about 24 hours for the bio reduction process at room temperature. The Pale-yellow colour solution slowly becomes brown colour. After 24 hours black precipitate is observed at the bottom which indicates the formation of nanoparticles [9]. The precipitate obtained was dried at room temperature and used for characterization

3. Results and Discussion

3.1 X-ray diffraction analysis

The Debye-Scherrer equation was utilized to compute the crystallite size using equation:

$$D = K\lambda / \beta \cos\theta$$

Where D, K, λ , β and θ corresponds to size of the crystallite, constant, X-ray wavelength, FWHM value and diffraction angle, respectively [10]. This was shown in the table 4.1. Hence, the average crystallite size of synthesized AgNPs is 43.52 nm and suggested that the AgNPs is microcrystalline nature.

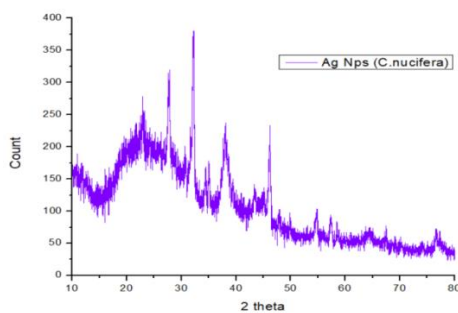


Fig.1. XRD Spectrum of AgNPs

Table 1. XRD values of silver nanoparticles

Peak position	FWHM	D-Value
54.825	0.233	35.53
49.890	0.100	86.62
39.440	0.216	38.5
76.571	0.208	39.6
57.336	0.222	37.45
18.812	0.213	38.5
35.068	0.177	47.79
34.411	0.181	46.2
27.752	0.182	46.2
37.987	0.324	25.2
46.184	0.191	43.3
32.181	0.219	37.45

3.2 UV-Visible analysis of silver nanoparticles

Absorption Spectrum of the synthesized AgNPs have absorbance at 290nm, broadening of peak indicated that the particles are poly dispersed.

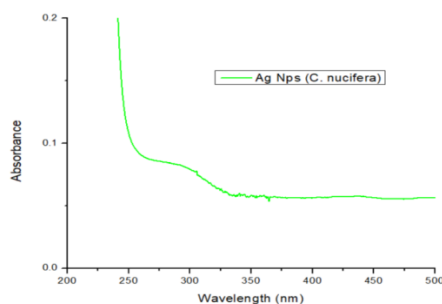


Fig. 2. UV-Vis spectrum of silver nanoparticles

3.3 FT-IR analysis of Silver nanoparticles

The FT-IR spectrum of the synthesised AgNPs shows bands at 3392, 3230, 2920, 2860, 2372, 1745 and 1575 cm^{-1} respectively (Fig. 3). It also confirms the bio reduction of silver ions in the presence of *Cocos nucifera* husk extract.

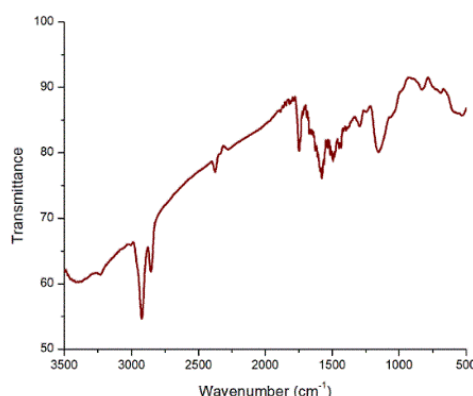


Fig.3 FT-IR Spectrum of AgNPs

3.4 Morphology studies (SEM)

Morphological examinations for the silver nanoparticles were carried out by using Scanning Electron Microscopy. The images display that all the prepared nanoparticles exhibit almost spherical shape. Also, the obtained SEM image display the formation of nanoparticles and some fiber extract residues.

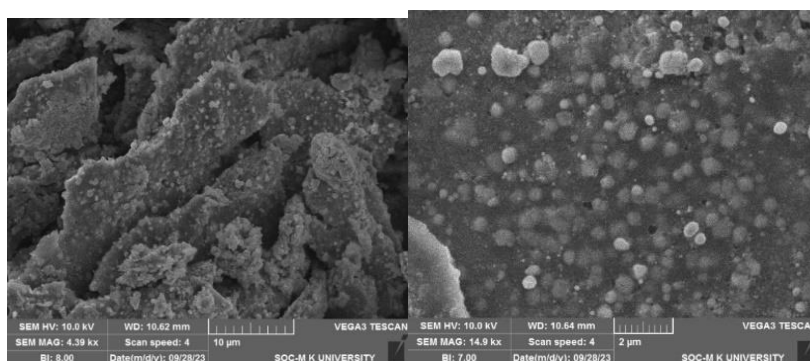


Fig. 4 SEM image of synthesized *Cocos nucifera* based silver nanoparticles

3.3.1 EDX Studies

The EDAX spectral image displayed the presence of metallic silver at 3KeV. The elemental dot mapping (Fig 4.5) of a selected area showed up 4%-N, 24.25%-O, 71.75%-Ag of the corresponding elements.

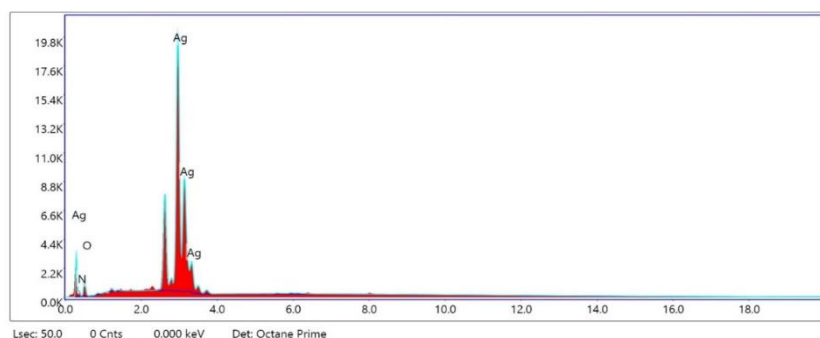


Fig.5 EDAX spectra showing elements present

3.5 Antimicrobial Activity

3.5.1 Zone of Inhibition of Silver nanoparticles from *Cocos nucifera*

The zone of inhibition AgNPs produced using the *Cocos nucifera* extract against Gram positive *B. subtilis* and Gram-negative *Proteus mirabilis* were studied using Chloramphenicol (10 μ g) as the control.

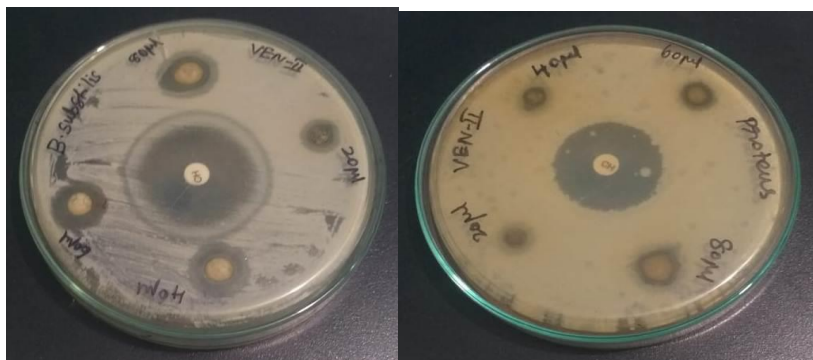


Fig. 6 Zone of Inhibition *Bacillus subtilis*, *Proteus mirabilis*

The antibacterial activity of AgNPs (100mg) against Gram positive *B. subtilis* was greater when compared with the Gram-negative *Proteus mirabilis* shown in table 2.

Table 2. Zone of inhibition of bacteria with varied concentration

Bacteria	20 μ l	40 μ l	60 μ l	80 μ l	Standard
<i>Bacillus subtilis</i> (Positive)	11	15	18	18	35
<i>Proteus mirabilis</i> (Negative)	7	9	10	12	25

The zone of inhibition AgNPs produced using the *Cocos nucifera* extract against *Rhizopus microsporus* and *penicillium* were studied using Chloramphenicol (10 μ g) as the control.



Fig. 7 Zone of inhibition *Rhizopus microsporus*, *Penicillium sp*

The antifungal activity of AgNPs (100 mg) against *Penicillium sp* was greater when compared with the *Rhizopus microsporus* shown in table 3.

Table 3. Zone of inhibition of fungi with varied concentration

Fungi	20µl	40µl	60µl	80µl	Standard
<i>Rhizopus microsporus</i>	12	14	16	18	20
<i>Penicillium sp</i>	123	14	16	21	30

4. Conclusion

The present investigation deals with synthesis and characterization of silver nanoparticles using *Cocos nucifera* and its antimicrobial activity. The experiment which was conducted to examine the formation of AgNPs and it was characterized by UV, FT-IR, XRD and SEM. From the UV spectroscopy, the synthesised AgNPs has high absorbance at 290 nm ($\pi-\pi^*$ transition). It was mentioned that the methods of preparing AgNPs is simple and convenient. The FT-IR data for the AgNPs closely matched the suggested structure. From FT-IR, we can confirm that functional groups such as -NH, -CH, -CH₃, -CO, -NH₃⁺ were present in the synthesised AgNPs. From XRD we evaluated the average crystalline size using Scherer formula as 43.52 nm. The SEM images of AgNPs showed almost spherical shaped surface morphology. The Antimicrobial activity of bacteria *Bacillus subtilis* (Gram positive), *Proteus mirabilis* (Gram positive) and fungi *Rhizopus microsporus*, *Penicillium sp* were studied using bio synthesized AgNPs. The results showed that the AgNPs have higher inhibition against gram positive *B. Subtilis* than with the Gram-negative *Proteus mirabilis*. The antifungal activity of AgNPs against *Penicillium sp* was found to be greater when compared with the *Rhizopus microsporus*.

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α -Cyclodextrin Complexation - A Viable Route to Taste Masking of Bitterness of Chlorpheniramine Maleate

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ABSTRACT

Improving patient compliance with significant therapeutic value is highly important to be in concern while developing an oral dosage form. Undesirable taste of the drug can influence patient compliance and product quality. Health care providers are dealing with bitter drug issues while orally administering to each paediatric patients and elderly patients. Masking the unpleasant taste of bitter drugs is a potential tool for the enhancement of patient compliance and success of the product. Various approaches and methodologies of development for masking the undesirable taste of drugs with consideration of applications, evaluation, and technologies for taste masking. This investigation evaluates inclusion complexation by α -cyclodextrin as a masking agent for Chlorpheniramine Maleate.

Keywords: Taste masking, Inclusion complex, Chlorpheniramine Maleate, α -Cyclodextrin

Introduction

Paediatrics and elderly patients specifically are difficult to control while administering the unpleasant taste of specific drug, leading to administer fewer doses, which cause less efficiency. Taste masking is the proper way to improve the quality of the treatment [1]. The taste masking defined as a perceived decrease of an unpleasant taste of active pharmaceutical ingredients [2]. There are various taste-masking techniques which may be used to inhibit bitter taste [3]. For solid oral dosage forms, polymer coating of capsules and tablets or monolithic systems such as polymer or lipid extrudates may be used; these approaches may be of less use for paediatric patients for whom swallowing solid dosage forms can be challenging. Among the various taste masking strategies inclusion complex formation is an efficient approach in dealing with patient's compliance. These inclusion complexes can enhance drug solubility, mask bitter taste of the active pharmaceutical ingredient (API) and prevent degradation of drug molecules. Usually, the formation of inclusion complex method is used when low dose drug is required. This technique works by the host and guest link, where the host is the complexing agent; and the guest is the active moiety. The purpose of the complexing agent is to mask the unpleasant taste of specific drug either by reducing its oral solubility or reducing the amount of the drug particles to taste buds. The most commonly

used complexing agent is cyclodextrin, due to its sweet in taste, non-toxic, and cyclic oligosaccharide acquired from starch. In inclusion complexes, the Vander Waals forces are predominantly involved [4-6].

Chlorpheniramine Maleate is an antiallergic medication. It appears as Odor less white crystalline solid or white powder with a bitter taste and has poor patient compliance. Chlorpheniramine maleate (CPM) is a first-generation alkyl amine widely used as antihistamine drug patients to inhibit various histaminic actions [7]. Apart from the most common side effects possess by all the antihistamines, CPM has a major problem related to its oral bioavailability [8]. However, it is well absorbed from the gastrointestinal tract, its oral bioavailability is only 25-40% of the orally administered dose which is due to its high first pass metabolism [9]. Chlorpheniramine Maleate works by blocking the action of histamine, thereby relieving these symptoms. In this study, α -Cyclodextrin is used to mask the bitter taste of Chlorpheniramine Maleate and it is illustrated in Fig. 1.

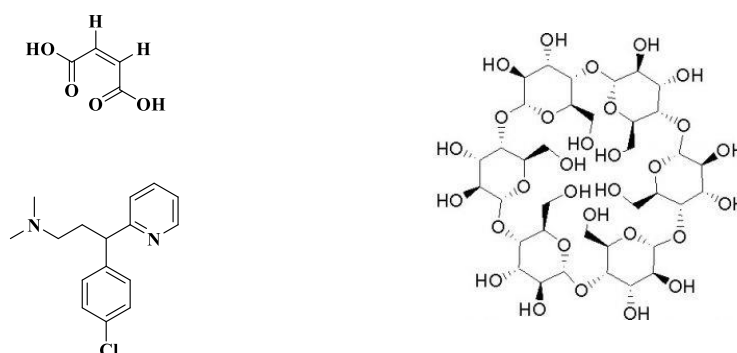


Fig.1 Structure of Chlorpheniramine Maleate and α -Cyclodextrin

Materials and Methods

ChlorpheniramineMaleate and α -Cyclodextrin purchased from Sigma Aldrich were used for the studies. The solvents used were of analytical grade. Triply distilled water was used for the preparation of stock solutions.

Instruments

1. Systronics Smart Double Beam Spectrophotometer-2203
2. JASCO Spectrofluorometer FP-8200.

Preparation of liquid inclusion complex of Chlorpheniramine maleate: α -CD

About 0.0054g of Chlorpheniramine maleate was accurately weighed and dissolved in 10mL ethanol. About 0.2918g of α -CD was dissolved in 30mL distilled water in a 250mL beaker. Inclusion complexes of Chlorpheniramine maleate: α -CD were prepared by varying the concentration of α -CD from 2×10^{-3} M to 1×10^{-2} M with Chlorpheniramine maleate.

Preparation of solid inclusion complex of Chlorpheniramine maleate: α -CD

About 0.02g of Chlorpheniraminemaleate was accurately weighed and dissolved in 30mL of methanol and about 0.2918g of α -CD was dissolved in 30mL distilled water in a 250mL beaker. Both the solutions were mixed together in a beaker and put over electromagnetic stirrer to stir continuously for 48h at room temperature. The precipitate formed after evaporation was dried and used for characterization.

Results and Discussion

UV-VIS Spectral Analysis of Chlorpheniramine maleate: α -CD

Absorption spectra were used to confirm the formation of inclusion complex. The complexation causes a change in the absorption spectrum of a guest molecule. During the spectral changes, the chromophore of the guest is transferred from an aqueous medium to the non-polar cyclodextrin. These changes must be due to a perturbation of the electronic energy levels of the guest caused either by direct interaction with the cyclodextrin, by the exclusion of solvating water molecules or by a combination of these two effects [10,11]. Small shifts are observed on the UV spectra of the included guests, the method is often used to detect inclusion complexation. In this study, absorption spectra of α -CD, chlorpheniramine maleate and inclusion complexes were taken into consideration. The absorption spectra of the inclusion complexes formed between chlorpheniramine maleate and α -CD are shown in Fig.2. The spectral data are tabulated in Tab.1. An absorption peak is obtained at λ_{abs} 252 nm. After the addition of α -CD, the absorption spectra are bathochromically shifted with increase in intensity. With the increase in concentration of α -CD, the intensity of absorbance also increased. It is inferred that the solubility of chlorpheniramine maleate increases with increase in the concentration of α -CD. Spectral shifts are indicative of the inclusion complexes formed between chlorpheniramine maleate and α -CD.

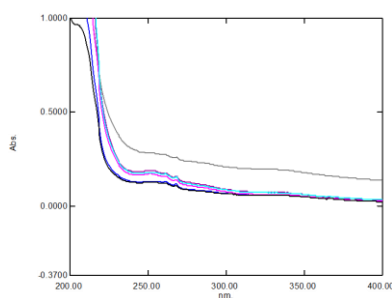


Fig.2. Absorption spectra of chlorpheniramine maleate with varying Concentrationsof α -CD

Table.1 Absorption spectral data of chlorpheniramine maleate with varying concentrations of α -CD

S. No	Concentration of α -CD	λ_{abs}	Absorbance	A-A ₀	$\frac{1}{A-A_0}$	Log E	$\frac{1}{[\alpha\text{-CD}]}$
1	0	247	0.175			3.65	
2	0.002	247.4	0.200	0.025	40	3.71	500
3	0.004	248	0.215	0.040	25	3.74	250
4	0.006	248.7	0.240	0.065	15.3	3.79	166.6
5	0.008	249	0.255	0.080	12.5	3.82	125
6	0.010	250	0.300	0.125	8	3.89	100

Determination of binding constant

The binding of Chlorpheniramine α -CD inclusion complexes has been studied by absorption spectral technique using Benesi-Hildebrand equation [12].

$$\frac{1}{A-A_0} = \frac{1}{A'-A_0} + \frac{1}{K_B(A'-A_0)[\alpha\text{-CD}]}$$

Where,

A₀- initial absorbance; A, A'-observed absorbances; K_B- binding constant [α – CD]-Concentration of α -CD. The binding constant calculated was found to be 96 M⁻¹.

Determination of the stoichiometry of the inclusion complex

The stoichiometry of the inclusion complex, A plot of $\frac{1}{A-A_0}$ versus $\frac{1}{[\alpha\text{-CD}]}$ for absorption gives good linear correlation indicating the stoichiometry for the formation of 1:1 guest host inclusion complex. The stoichiometry can be obtained by using the Benesi-Hildebrand equation which was shown in Fig. 3.

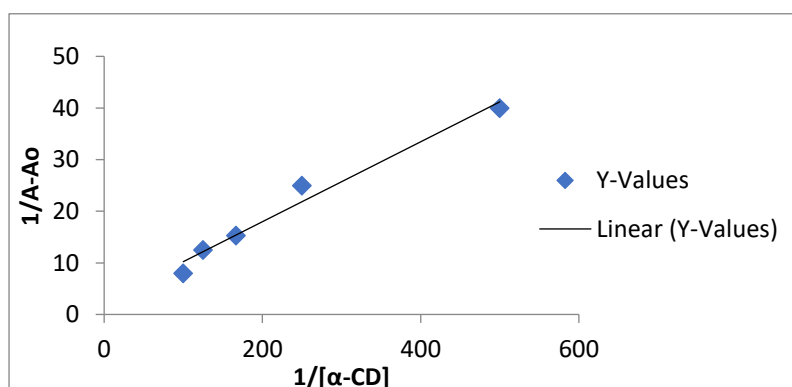


Fig.3. Benesi-Hildebrand plot of Chlorpheniramine maleate: α -CD inclusion complexes

FTIR Spectral Analysis of inclusion complexes of chlorpheniramine maleate: α -CD.

FTIR is a very useful tool to prove the existence of both guest and host molecules in their inclusion complexes Fig 4,5,6 shows the FTIR spectra for the α -CD, chlorpheniramine maleate, inclusion complex of chlorpheniramine maleate: α -CD. The pure drug chlorpheniramine maleate exhibited the peaks at 2924.27 cm^{-1} for C-H aromatic stretching, 650.34 cm^{-1} , 944.87 cm^{-1} for C=C characteristic peaks, 3340.71 cm^{-1} for O-H stretching of Maleate salt, 1703.38 cm^{-1} for C=O and 769.6 cm^{-1} for C-Cl bending. The same peaks of the chlorpheniramine maleate were observed in the inclusion complex with slight shifts in wavelength. The inclusion complex shows a broadened O-H band with change in values from 3400 cm^{-1} to 3394.72 cm^{-1} which indicates that there is intermolecular hydrogen bonding between chlorpheniramine maleate and α -CD.

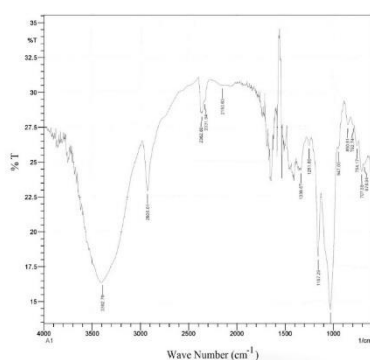


Fig.4 FTIR Spectra of α -CD

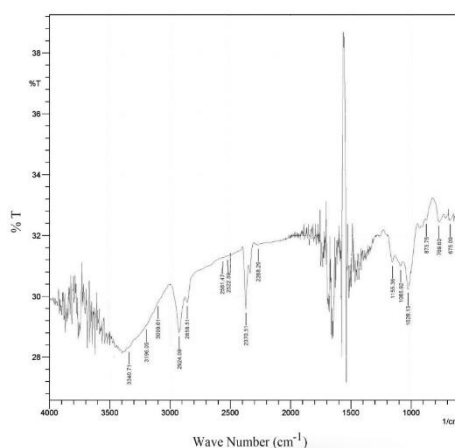


Fig.5 FTIR Spectra of chlorpheniramine maleate

Significant changes are observed in the area between 1600 and 1400 cm^{-1} assigned to C=C aromatic stretching in free due to the interaction between this region of the drug and cyclodextrin cavity and an enlargement of the bands at 1030 cm^{-1} of the is observed due to the

establish of interaction during complexes formation [13]. No new peaks appeared which indicates that no bonds are formed or broken during inclusion complex formation.

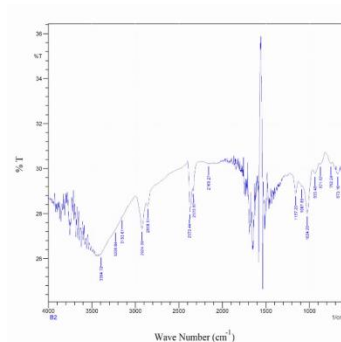


Fig.6 FTIR Spectra of inclusion complex of chlorpheniramine maleate: α -CD

Thin Layer Chromatographic Studies

Thin layer Chromatography also serves as a tool for the inclusion complex formation. The R_f values are calculated for pure drug and the inclusion complexes. The thin layer chromatogram for pure drug and inclusion complex in the ratio of 1:1 diethyl ether: water, chloroform: water, ethyl acetate: water are shown in Fig.7,8 and 9. In all the cases, the R_f values of inclusion complexes are found to be less than that of pure Chlorpheniramine maleate [14]. This is a strong indication that inclusion complexes are formed between Chlorpheniramine maleate and α -CD. Further, the R_f values obtained for chlorpheniramine maleate and chlorpheniramine maleate: α -CD was tabulated in Table 2.

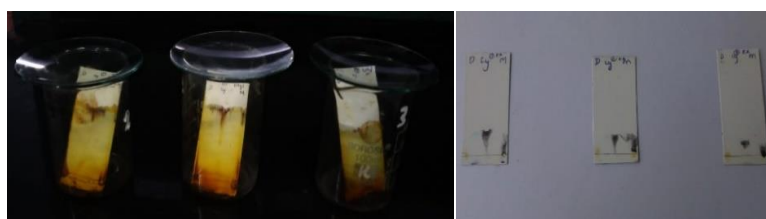


Fig.7 Thin Layer Chromatography images of chlorpheniramine maleate and chlorpheniramine maleate: α -CD in the ratio of 1:1 diethyl ether: water



Fig.8 Thin Layer Chromatography images of chlorpheniramine maleate and chlorpheniramine maleate: α -CD in the ratio of 1:1 chloroform: water, ethyl acetate: water



Fig.9 Thin Layer Chromatography images of chlorpheniramine maleate and chlorpheniramine maleate: α -CD in the ratio of 1: 1, ethyl acetate: water

Table.2 Thin layer chromatographic data

solvent	α -CD R_f	CPM R_f	CPM: α -CD R_f
Diethyl ether Phosphate water50:50v/v	0.2345	0.2673	0.2009
CD Chloroform Phosphate water50:50v/v	0.2876	0.2939	0.1978
Ethyl acetate Phosphate water50:50v/v	0.3045	0.3155	0.2987

CPM-chlorpheniramine maleate

The complexing agent α -Cyclodextrins a sweet, non-toxic, starch-derived cyclic oligosaccharide. Bitterness elimination is depended upon the extent of complexation of guest molecule with host, value of complex association constant temperature and the host/guest ratio. chlorpheniraminemaleate forms a 1:1 complex with cyclodextrins, more than 99 % of the bitter drug is complexed with cyclodextrins and as complexed molecule chlorpheniramine maleate cannot react with the taste bud in the buccal cavity, no bitter taste perceived [15,16] and thereby suppression of bitter taste by alpha-cyclodextrin [17]. The complexing agent α -Cyclodextrin is capable of masking the bitter taste of the drug by either decreasing its oral solubility on ingestion or decreasing the amount of drug particles exposed to taste buds thereby reducing the perception of bitter taste. Vander Waals forces are mainly involved in inclusion complexes [18-20].

Conclusion

The absorption spectra provide ample information regarding the formation of inclusion complexes of chlorpheniraminemaleate with α -CD. The binding constants were

calculated using the Benesi Hildebrand equation and it was found to be 96.5 M^{-1} . The linear correlation of the Benesi-Hildebrand plot indicates that the inclusion complexes formed were in the stoichiometric ratio 1:1. Considerably higher binding constant values showed the formed inclusion complexes were quite stable. The stability of the inclusion complexes formed shows that the solubility of chlorpheniramine maleate is also further increased upon complexation with α -CD. The formation of inclusion complexes between chlorpheniramine Maleate and α -CD was further confirmed by FTIR studies and thin layer chromatographic studies. Thus it paves the way to remove undesirable bitter effects the drug chlorpheniramine Maleate and enable us to have sustained controlled release of the drug and hence oral bioavailability of the drug. Bitterness elimination is depended upon the extent of complexation of guest molecule with host, value of complex association constant temperature and the host/guest ratio. chlorpheniramine maleate forms a 1:1 complex with α -cyclodextrin, more than 99 % of the bitter drug is complexed with α -cyclodextrin and as the complexed molecule. chlorpheniramine maleate cannot react with the taste bud in the buccal cavity, no bitter taste is perceived and suppression of bitter taste was done by alpha-cyclodextrin.

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**Preliminary phytochemical analysis and antibiogram of the seagrass
Syringodium isoetifolium (Asch.) Dandy collected from
Kooduthalai Coast, Tirunelveli.**

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ABSTRACT

*Seagrasses are marine flowering plants and are distributed all over the world. They are well documented for the presence of potent, diverse secondary metabolites that are biologically active and could be used as potential drugs. The present study is about the investigation of the phytochemicals and antibacterial activity of the seagrass *Syringodium isoetifolium*. The dried seagrass powder was extracted with chloroform, acetone and ethanol separately in a ratio of 1:4 using a cold extraction method. The preliminary phytochemical analysis of the extracts showed the presence of alkaloids, steroids, saponins, flavonoids, terpenoids, glycosides and phenolic compounds. Antibacterial activity was done using a well diffusion method against one Gram-positive and one Gram-negative pathogens, such as *Bacillus subtilis* and *Pseudomonas aeruginosa*. Among the three solvent extracts, the ethanol extract showed the maximum activity of 19.66 ± 0.57 mm against *B. subtilis*. This study revealed that the seagrass *Syringodium isoetifolium* has very good antimicrobial activity due to its secondary metabolites.*

Keywords: Seagrass, Antimicrobial activity, *Syringodium isoetifolium*

1. Introduction

Seagrass is one of the true marine flowering plants that belongs to the group angiosperms [1]. They are known to produce a wide variety of secondary metabolites that aid as defense mechanisms under stress conditions and these compounds are found to be anti-oxidative in nature [2]. These chemical compounds synthesized by secondary metabolic pathways are not involved in normal growth, development or reproduction but usually have roles in adaptation processes under stress conditions [3]. These biogenic compounds or active metabolites like polyphenols, terpenoids and halogenated compounds produced by several species of seagrass have anticancer (antitumor), antifungal or anti-inflammatory [4], antimicrobial [5], antiviral, antidiabetic activities [6], antimalarial, antioxidant [7], antiprotozoal and cytotoxic properties [8] which are effective in the prevention of different diseases and also other novel pharmacological activities. It has been realised that many of these metabolites, being biologically active, could be used as a potential drug. As antibiotic resistance has developed,

it demands a continued search for antibacterial drugs that combat harmful microorganisms [9]. Thus, we continue to require more effective, affordable, and safe medications. Therefore, the purpose of this study was to assess the antibacterial activity of the seagrass *Syringodium isoetifolium* (Asch.) Dandy against human infectious disease pathogens such as *Pseudomonas aeruginosa* and *Bacillus subtilis*, as well as examine its phytoconstituents.

Materials and methods

Sample collection and Extraction

The fresh leaves of *Syringodium isoetifolium* (Asch.) Dandy were collected from Kooduthalai coast, Tirunelveli, India and identified as *Syringodium isoetifolium* (Asch.) Dandy by morphological features according to the standard seagrass manual [10]. The collected seagrass was cleaned with tap water and shade dried. The dried materials were powdered using a mixer grinder. The powdered sample was extracted with organic solvents of increasing polarity such as chloroform, acetone and ethanol, individually in a ratio of 1:4. The extracts were filtered using Whatman No.1 filter paper. The resultant filtrate was then concentrated and used for further analysis.



Fig 1. Image of the seagrass *Syringodium isoetifolium*

Phytochemical Analysis

The qualitative test for the identification of phytochemical constituents was carried out according to standard procedure [11].

Microorganisms used

The antimicrobial activity of the seagrass extract was screened against one Gram-positive bacteria, *Bacillus subtilis* and one Gram-negative bacteria *Pseudomonas aeruginosa*, which were obtained from Scudder Laboratory, Nagercoil.

Antibacterial assay

Antibacterial activity was assayed using the agar well diffusion technique using Nutrient Agar Medium. A sterile cotton swab was used for spreading the test microorganisms evenly from the 24-hour incubated broth on the NA plates. In each of these plates, wells of

6mm diameter were made using a sterilized cork borer and 50 µl of each extract was added to those wells separately. 25 µl of streptomycin (10mg/ml) was used as a positive control and 25 µl of the respective solvent used as a negative control. The extract-loaded plates were kept for incubation at 37°C for 24 hours. After incubation, a clear zone around the well was formed which was the diameter of the zone of inhibition measured in millimetres. The experiment was carried out in duplicate and the mean zone of inhibition \pm standard error was calculated using excel.

2. Results

Table 1. Phytochemical analysis of *Syringodium isoetifolium*

S. No	Phytochemicals	Acetone	Chloroform	Ethanol
1	Alkaloids	-	+	+
2	Steroids	+	-	-
3	Tannins	-	-	-
4	Phlobatanins	-	-	-
5	Saponins	+	+	+
6	Flavonoids	+	-	+
7	Terpenoids	+	+	-
8	Glycosides	+	+	+
9	Phenolic compounds	+	+	+
10	Aromatic acids	-	-	-
11	Xanthoproteins	-	-	-

Phytochemical analysis was done separately for acetone, chloroform and ethanol extracts of *S. isoetifolium*. As Table 1. Shows, the acetone extract of the seagrass shows the presence of phytochemicals such as steroids, saponins, flavonoids, terpenoids, glycosides and phenolic contents. The chloroform extract shows the presence of alkaloids, saponins,

terpenoids, glycosides and phenolic compounds. The ethanol extract shows the presence of alkaloids, saponins, flavonoids, glycosides and phenolic compounds.

Table 2. Zone of inhibition (mm±SE) of *S. isoetifolium* on human pathogens

Bacteria	Control	Standard (Streptomycin)	Acetone (25µl)	Chloroform (25µl)	Ethanol (25µl)
<i>B. subtilis</i>	-	30	13±0.8	9±0.9	19.6±0.57
<i>P. aeruginosa</i>	-	17	9±1	8±0.6	14±1.2

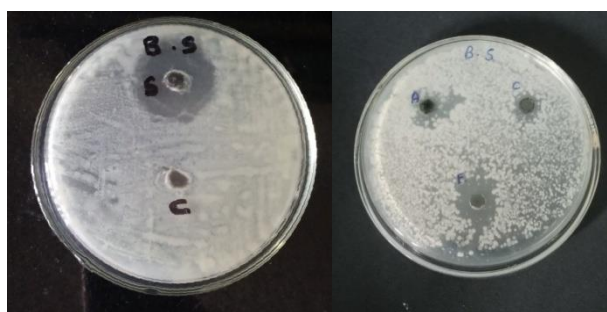
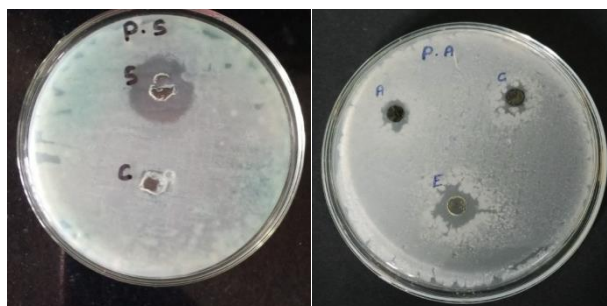


Fig. 2. Antibacterial activity of *S. isoetifolium* against *B. subtilis*



(S-streptomycin, C-control, A- acetone, C-chloroform, E-ethanol)

Fig. 3. Antibacterial activity of *S. isoetifolium* against *P. aeruginosa*

From Table 2. and Figs. 2 and 3, among the three solvent extracts, the ethanol extract showed the highest activity against both the tested pathogens, with the maximum activity of 19.66±0.57 mm against *B. subtilis*.

3. Discussion

Natural products are considered an important source of new antibacterial agents. Many chemically unique compounds of marine origin with different biological activities have been isolated and a number of them are under investigation and/or are being developed as new pharmaceuticals [12,13]. The present study revealed that the seagrass *S. isoetifolium* contains phytochemicals such as alkaloids, steroids, saponins, flavonoids, terpenoids,

glycosides and phenolic compounds. The qualitative phytochemical analysis showed that most of the phytoconstituents were extracted with acetone extraction compared to the other two.

Seagrasses have the highest value of soluble phenolic content which exhibit multiple bioactive roles against pathogenic microorganisms. In this study, the solvent extracts of seagrass *S. isoetifolium* displayed good antibacterial activity against Gram-positive as well as Gram-negative pathogens. Among the three solvents, the ethanol extract of *S. isoetifolium* effectively inhibited both *B. subtilis* (19.6 mm) and *P. aeruginosa* (14 mm). It is followed by acetone extract which inhibits *B. subtilis* (13 mm) effectively. The chloroform extract showed the lowest activity among the three extracts. Similar findings were also seen in some previous reports and also confirm that the polar solvents like methanol and ethanol extracts of seagrasses *Halophila ovalis* and *Halodule pinifolia* showed better zones of inhibition against pathogens than any other tested extracts [14]. Likewise, *Heracleum sphondylium*'s ethanol and aqueous extracts have shown antibacterial properties against both Gram-positive and Gram-negative bacteria [15]. The variation in antibacterial activity of the extracts might be due to the distribution of antimicrobial substances, which varied from species to species [16]. The present study reveals that the ethanol extract has effective inhibition of human pathogens and could be used to extract potent antimicrobial compounds. But previously, it was reported that the acetone and hexane leaf extracts were found to have the strong antimicrobial and anti-inflammatory activities [17]. The marine plant's antibacterial effect may be a result of phytochemicals present in plant extracts, which include alkaloids, tannins, flavonoids, and sugars [18].

4. Conclusion

The prospect of developing antimicrobials from plant extracts emerges satisfying, as it will lead to the development of phytomedicines to act against microorganisms. The sea grass *Syringodium isoetifolium* has a variety of biologically active molecules that can be used as a source of antibiotics. Further purification of active compounds and structural elucidation can be used for drug discovery.

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Antibacterial activity of the tissue extracts of Marine crab, *Lauridromia dehaani*

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ABSTRACT

*The search for antimicrobial agents has taken a definite direction and marine crabs have been found to possess antimicrobial activity against pathogens like bacteria, fungi and viruses. The present investigation was taken up to study the antibacterial potential of different solvent extracts of haemolymph, gills, muscle, and hepatopancreas of *Lauridromia dehaani*. Five human pathogenic bacteria such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis* and *Klebsiella pneumoniae* were used for antibacterial studies. Maximum zone of inhibition was observed with the acetone extracts of gills. Chloroform and aqueous extracts of the tissues also recorded moderate antibacterial activity. Thus, the results revealed that *Lauridromia dehaani* has potential antibacterial compounds.*

Keywords: Antimicrobial, *L. dehaani*.

1. Introduction

The emergence of new infectious diseases and resistance to antibiotics by the existing ones led to the development of new drug discovery [1]. Antimicrobial peptides are important in the first line of the host defense system of many animal species. Their value in innate immunity lies in their ability to function without either high specificity or memory. Moreover, their small size makes easy to synthesize without dedicated cells or tissues and they rapidly diffuse to point of infection [2]. Recent experimental data from invertebrates suggests the past exposure to pathogens in individual animals can lead to enhanced immunity and some are also known to have considerable specificity by recognizing non-self pathogen associated receptors that are highly conserved in evolution [3]. Some of the known innate responses in invertebrates include phagocytosis, nodulation and encapsulation, synthesis of AMP and activation of proteolytic cascades that lead to melanisation, blood coagulation, release of stress responsive proteins and molecules believed to function in opsonization and iron sequestration [4].

The crabs are in intimate contact with aquatic environment rich in pathogenic microbes and are prone to infection by those microbes at various stages of growth, and losses

due to disease can be enormous [5]. An over the past several years, many antimicrobial peptides have been found and characterized in crab species. The first antimicrobial peptide characterised was a proline peptide of 6.5 KDa from the haemocytes of the shore crab *Carinus maenas*. The antimicrobial peptide Callinecin is a cationic antimicrobial peptide of 3.7 KDa isolated from the blue crab, *Callinectes sapidus*. Recently, scygonadin, an anionic antimicrobial peptide isolated from seminal plasma of the mud crab *Scylla serrata* [6]. Marine crabs are potential sources of new antibiotics. The search for antimicrobial agents has taken a definite direction in developed countries. The first line of defense of arthropods against pathogens and parasites is of physical nature via their hard cuticle. However, once this barrier is passed, a complex interaction of innate humoral and cellular immune reactions is induced in both tissues and haemocoel, which results in a fast elimination of micro-organisms. Antimicrobial activity has been detected in several decapod crustaceans, including lobster, crabs, shrimps and freshwater cray fish [7, 8]. Marine crabs are rich sources of new antibiotics [9] but only few studies were carried out on the bioactivity of crustaceans [10, 11]. Recent research findings suggest that marine crabs are a potential source of new antibiotics for pharmaceutical development. However, the marine organisms recognized as a potential source of biologically active substances, is largely unexplored. Hence, a broad-based screening of marine crabs for bioactive compounds has become a necessity. Kanyakumari is a rich source of marine reserves since this study focused on the antimicrobial activity of the marine crab, *Lauridromiadehanni* commonly found in the coast of Kanyakumari District, Tamilnadu, India.

2. Materials and Methods

2.1 Experimental animal and sample collection

Lauridromia dehanni were collected from Manakudi coastal area, Kanyakumari District, Tamil Nadu, India in the month of April 2022. Haemolymph was collected by cutting walking legs of the crab with a fine sterile scissor. The haemolymph collected was centrifuged at 2000 rpm for 15 minutes at 4°C to remove haemocytes from the haemolymph. Supernatant was collected and stored at 4°C until use. Gills, muscle and hepatopancreas were carefully dissected and stored at 20°C prior to extraction for antibacterial work.

Lauridromia dehanni



2.2 Preparation of extracts for antimicrobial activity

Tissue extracts of the crab were prepared following the method of Karthikeyan *et al.* (12) with slight modification. 1 g each of gills, muscle and hepatopancreas were homogenized and extracted with 10 volumes (v/w) of acetone, chloroform and aqueous and kept for three days at room temperature. The extracts were filtered through Whatman No 1 filter paper, concentrated by evaporating in room temperature to give a dark gummy mass and used for the antibacterial assay. Haemolymph was treated with all the above-mentioned solvents (1:1) and used for antimicrobial studies.

2.4 Bacterial strains

Antibacterial activity of crab was determined against five bacterial strains viz., *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis* and *Klebsiella pneumoniae*. These pathogens strains were obtained from the Scudder Laboratory, Nagercoil.

2.4 Assay of antibacterial activity

Antibacterial activity was analysed by following the standard disc diffusion method Bauer et al., 1996, (13) 20 ml of sterilized Muller Hinton Agar was poured into sterile petri-plates. After solidification 100 µl of fresh culture of pathogenic bacteria (*E. coli*, *P. aeruginosa*, *S. aureus*, *B. subtilis*, *K. pneumoniae*) were swabbed on the respective Muller Hinton Agar plates. The discs impregnated with 50 µl of samples were kept over the agar plates using sterile forceps. Streptomycin was used as positive control. The plates were incubated for 24 hours at 37°C. After incubation the diameter of inhibitory zones formed around each disc were measured (mm) and recorded.

Results

3.1 Antibacterial activity of haemolymph

The acetone haemolymph extract of *Lauridromia dehaani* showed high antibacterial activity on *E. coli* (9±0.25 mm) followed by *S. aureus* (7±0.5 mm). The acetone haemolymph extract did not inhibit the growth of *P. aeruginosa*, *K. pneumoniae* and *B. subtilis*. They did not show inhibitory activity against other extracts tested (Table 1).

3.2 Antibacterial activity of gills

The acetone extract of gills inhibited the growth of *B. subtilis* (11±0.25 mm), followed by *K. pneumoniae* (9±0 mm). However, it did not show inhibitory activity against *E. coli*, *S. aureus* and *P. aeruginosa*. Aqueous extract of gills inhibits the growth of *K. pneumoniae* (7±1 mm) only (Table 2).

3.3 Antibacterial activity of muscle

The acetone extract of muscle inhibited the growth of *S. aureus* (5 ± 0.25 mm), followed by *P. aeruginosa* (4 ± 0 mm). However, it did not show inhibitory activity against *E. coli*, *K. pneumonia* and *B. subtilis*. The chloroform extract inhibited the growth of *S. aureus* and *P. Aeruginosa* only. Aqueous extract of muscle inhibited the growth of *B. subtilis* (6 ± 1 mm) only (Table 3).

Antibacterial activity of hepatopancreas

Chloroform extract of hepatopancreas showed antibacterial activity against *S. aureus* (7 ± 0.25 mm), followed by *P. aeruginosa* (6 ± 0.25 mm). The aqueous extract inhibited the growth of *S. aureus* (5 ± 0.25 mm) followed by *P. aeruginosa*. The acetone hepatopancreas extract did not inhibit the growth of tested microbes (Table 4).

Table 1: Antimicrobial activity of haemolymph of *Lauridromia dehaani* against tested pathogens

Pathogen	Strain of pathogen	Zone of inhibition (mm)			
		Acetone	Chloroform	Aqueous	Positive control
Bacteria	<i>Escherichia coli</i>	9 ± 0.25	-	-	6 ± 0.5
	<i>Pseudomonas aeruginosa</i>	-	-	-	5 ± 0.5
	<i>Staphylococcus aureus</i>	7 ± 0.5	-	1	1 ± 0.25
	<i>Bacillus</i>	-	-	-	14 ± 0.25
	<i>Klebsiella pneumoniae</i>	-	-	-	13 ± 0.5

Table 2: Antimicrobial activity of gills of *Lauridromia dehaani* against Tested pathogens

Pathogen	Strain of pathogen	Zone of inhibition (mm)			
		Acetone	Chloroform	Aqueous	Positive control
Bacteria	<i>Escherichia coli</i>	-	-	-	1 ± 1
	<i>Pseudomonas aeruginosa</i>	-	-	-	-
	<i>Staphylococcus aureus</i>	-	-	-	110.25
	<i>Bacillus</i>	11 ± 0.25	-	-	90.25
	<i>Klebsiella pneumoniae</i>	9 ± 0	-	7 ± 1	9 ± 1

Table 3: Antimicrobial activity of muscle of *Lauridromia dehaani* Against tested pathogens

Pathogen	Strain of pathogen	Zone of inhibition (mm)			
		Acetone	Chloroform	Aqueous	Positive control
Bacteria	<i>Escherichia coli</i>	-	-	-	11 ± 0.25
	<i>Pseudomonas aeruginosa</i>	4 ± 0	6 ± 0.25	-	5 ± 0.25
	<i>Staphylococcus aureus</i>	5 ± 0.25	7 ± 0.25	-	5 ± 0.25
	<i>Bacillus</i>	-	-	6 ± 1	9 ± 1
	<i>Klebsiella pneumoniae</i>	-	-	-	1 ± 1

Table4: Antimicrobial activity of hepatopancreas of *Lauridromia dehaani* Against tested pathogens

Pathogen	Strain of pathogen	Zone of inhibition (mm)			
		Acetone	Chloroform	Aqueous	Positive control
Bacteria	<i>Escherichia coli</i>	-	-	-	85±0.25
	<i>Pseudomonas aeruginosa</i>	-	6±0.25	4±0.25-	55±0.25
	<i>Staphylococcus aureus</i>	-	7±0.25	5±0.25	75±0.1
	<i>Bacillus</i>	-	-	-	125±0.25
	<i>Klebsiella pneumoniae</i>	-	-	-	55±0.1

Discussion

In recent years, great attention has been paid to study the bioactivity of natural products due to their potential pharmacological utilization. The present research investigation is made on the basis of in search of antimicrobial peptides from the hemolymph and other tissues of a marine crab *Lauridromia dehaani* collected from the Manakudy coastal area, Kanyakumari district. The results revealed that the hemolymph, hepatopancreas, gills and muscles of the crab had antibacterial activity against different range of bacterial strains. Previous work shows that decapod crustaceans contain factors with antibacterial activity in the hemolymph and different body parts [14]. The influence of crab hemolymph against wide range of clinical pathogens proves that crustaceans are very good source of antimicrobial potency [15]. Antibacterial peptides can also be induced in response to wounding or infection in the cuticles [16] and these are secreted into the hemolymph of which some are lysozyme [17] and andropin [18]. These proteins show strong resistance to the microbial growth.

From the present study it was observed that *Lauridromia dehaani* has potential antibacterial components which are evident from the high zone of inhibition recorded with the solvent extract of haemolymph, gills, muscle, and hepatopancreas against human pathogens. The acetone extracts showed better results when compared to chloroform, aqueous suggesting acetone solvent as efficient in eluting the bioactive compounds. Our results are in confirmation with [19 and 20] who studied the antibacterial and antifungal activity of bioactive compounds of *A. integerrimus*.

Haemolymph of crustaceans has potential to act against wide range of clinical pathogens thereby making them reliable candidate for very good source of antimicrobial potency. These results indicate that crabs have developed a variety of defense molecules in haemolymph against pathogenic microorganisms. From the pharmacological point of view, it is advantageous, antimicrobial drugs have no side effects. The present study indicates that

haemolymph and tissue extracts of *Lauridromia dehannimay* contain potential antibiotics. The antimicrobial assay done so far will serve as a baseline data for further studies that may confirm the hypothesis that brachyuran crabs are indeed potential sources of novel compounds with biological potential. Further purification of the active compounds is necessary in order to identify their chemical nature and to evaluate their potency as novel drug.

Conclusion

The present study indicates that haemolymph and tissue extracts of *Lauridromia dehannimay* contain potential antibiotics. The antimicrobial assay done so far will serve as a baseline data for further studies that may confirm the hypothesis that brachyuran crabs are indeed potential sources of novel compounds with biological potential. Further purification of the active compounds is necessary in order to identify their chemical nature and to evaluate their potency as a novel drug.

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Anisotropic Diffusion-Based Image Processing for Brain Tumour Detection Using Partial Differential Equations

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ABSTRACT

Recently, there has been an increased focus on developing logical communication between humans and computers. The vision-based interface technology extracts additional information from an input image without the use of expensive hardware. As a result, a vision-based approach is considered an effective way to advance human computer interaction systems. This paper describes image processing using anisotropic diffusion and by applying partial differential equations the brain tumour and the type of tumour in the image is detected. By Using the MATLAB toolbox and functions correctly we can process and analyze images both quickly and accurately in real time.

Keywords: Anisotropic diffusion, MATrix LABoratory, medical imaging techniques

1. Introduction

Software for high-performance numerical computing and visualization is available under the name MATLAB. With hundreds of built-in functions for technical computation, graphics, and animation, it offers an interactive environment. The best part is that it also offers simple extension using a high-level programming language of its own. MATrix LABoratory is the meaning behind the term MATLAB.

The creators of MATLAB additionally offer a number of extra "toolboxes" that are optional. For specific applications including symbolic computation, image processing, statistics, control system design, and neural networks, these toolboxes are sets of functions. The number of toolboxes is continuously expanding. These toolboxes now number over 50.

Partial Differential Equations (PDES)

Anisotropic diffusion is often described using a partial differential equation that models the behavior of the image over time. The most commonly used PDE in anisotropic diffusion is the Perona-Malik equation [1]

$$\partial I / \partial t = \nabla \cdot (c(\|\nabla I\|) \nabla I)$$

Where

I - is the image intensity,

t - is time,

∇ - is the gradient operator

$C(\|\nabla I\|)$ - is the diffusion coefficient that varies based on the gradient magnitude

$\|\nabla I\|$. - represents the dot products and

∇I . - Represents the divergence

2. Materials and Methods

Brain Tumour

A brain tumour is a mass or growth of abnormal cells in the brain, which are what make up a human body. For medical and scientific research, the interior of the human body is visualized using medical imaging techniques, and this technology can also be used to identify non-invasive conditions. The numerous medical imaging technologies, such as MRI, Ultrasound, CT scan, SPECT, PET, and X-ray, are based on non-invasive methods. MRI pictures can be used to detect brain tumours. The detection of brain cancers using image processing methods is the main topic of this research.

Image Processing

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. Image processing is one form of signal processing in which the input is a photograph or video frame; the output may be either an image or a set of characteristics or parameters related to the image. An image contains sub-images sometimes referred as regions-of-interest, or simply regions this implies that images contain collections of objects each of which can be the basis for a region [2].

Pre-processing:

Image pre-processing aims to improve the image data by suppressing the undesired distortions and enhances some of the image features that will be helpful in further processing. The goal of Pre-processing is to remove the noise and to provide Contrast Enhancement to improve the image quality. The functions performed by preprocessing process is Gray scale conversion, Noise removal and Contrast Enhancement [3].

Image Segmentation

After pre-processing segmentation is applied to partition the image into multiple segments (sets of pixels, also known as super pixels) to simplify the representation of an image into something that is more meaningful and easier to analyse. Image segmentations typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics [4].

Anisotropic Diffusion

Anisotropic diffusion involves mathematics from partial differential equations (PDEs) and numerical methods. The primary mathematical concepts used in anisotropic diffusion are related to partial differential equations and gradient descent-based algorithms.

2.1. Input For Matlab Anisotropic Diffusion

```
Function diff_im=anisodiff (im, num_iter, delta_t, kappa, option)
fprintf ('Removing noise\n');
fprintf ('Filtering Completed !!');
%Conver tinput image to double.
im = double (im);
%PDE (partial differential equation) initial condition.
diff_im = im;
%Center pixel distances.
dx = 1;
dy =1;
dd =sqrt (2);
%2 Dconvolutionmasks -finite difference
hN=[0 10; 0-1 0; 0 0 0];
hS=[0 00; 0-1 0; 0 1 0];
hE=[0 00; 0 -1 1; 0 0 0];
hW=[0 00; 1 -1 0; 0 0 0];
hNE=[0 01; 0 -1 0; 0 00];
hSE=[0 00; 0-1 0; 0 0 1];
hSW=[0 00; 0-1 0; 1 0 0];
hNW=[1 00; 0 -1 0; 0 0 0];
% Anisotropic diffusion.
for t = 1:num_iter
% Finite differences. [imfilter(...,'conv')can be replaced by conv2(...,'same')]
nablaN = imfilter(diff_im,hN,'conv');
nablaS = imfilter (diff_im, hS,'conv');
nablaW = imfilter (diff_im, hW,'conv');
nablaE = imfilter (diff_im, hE,'conv');
nablaNE = imfilter (diff_im, hNE,'conv');
nablaSE = imfilter (diff_im, hSE,'conv');
```



```

nablaSW = imfilter (diff_im, hSW,'conv');
nablaNW = imfilter (diff_im, hNW,'conv');
%Diffusion function.
if option == 1
cN = exp (-(nablaN/kappa).^2);
cS = exp(-(nablaS/kappa).^2);
cW = exp(-(nablaW/kappa).^2);
cE = exp(-(nablaE/kappa).^2);
cNE=exp(-(nablaNE/kappa).^2);
cSE = exp(-(nablaSE/kappa).^2);
cSW = exp(-(nablaSW/kappa).^2);
cNW=exp(-(nablaNW/kappa).^2);
elseif option ==2
cN = 1./(1 + (nablaN/kappa).^2);
cS = 1./(1 + (nablaS/kappa).^2);
cW = 1./(1 + (nablaW/kappa).^2);
cE = 1./(1 + (nablaE/kappa).^2);
cNE=1./(1+(nablaNE/kappa).^2);
cSE = 1./(1 + (nablaSE/kappa).^2);
cSW = 1./(1 + (nablaSW/kappa).^2);
cNW=1./(1+(nablaNW/kappa).^2);
end
% Discrete PDE solution.
diff_im=diff_im+...
    delta_t*(...
    (1/(dy^2))*cN.*nablaN + (1/(dy^2))*cS.*nablaS + ...
    (1/(dx^2))*cW.*nablaW + (1/(dx^2))*cE.*nablaE + ...
    (1/(dd^2))*cNE.*nablaNE + (1/(dd^2))*cSE.*nablaSE + ...
    (1/(dd^2))*cSW.*nablaSW + (1/(dd^2))*cNW.*nablaNW );
End
ForBrainTumour
Clc
closeall

```

```
clearall
%% Input
[I, path] =uigetfile('*.jpg','select a input image');
str=strcat(path,I);
s=imread(str);
figure;
imshow(s);
title('Input image','FontSize',20);
%% Filter
num_iter=10;
    delta_t=1/7;
    kappa = 15;
    option =2;
    disp('Preprocessing image please wait...');
    inp=anisodiff(s,num_iter,delta_t,kappa,option);
    inp = uint8(inp);
    inp=imresize(inp,[256,256]);
    if size(inp,3)>1
        inp=rgb2gray(inp);
    end
figure;
imshow(inp);
title('Filtered image','FontSize',20);
%% thres holding
sout=imresize(inp,[256,256]);
t0=mean(s(:));
th=t0+((max(inp(:))+min(inp(:)))/2);
for i=1:1:size(inp,1)
    forj=1:1:size(inp,2)
        if inp(i,j)>th
            sout(i,j)=1;
        else
            sout(i,j)=0;
        end
    end
end
```

```
end
end
%%Morphological Operation
label=bwlabel(sout);

stats=regionprops(logical(sout),'Solidity','Area','Bounding Box');

density=[stats. Solidity];

area=[stats. Area];

high_dense_area=density>0.7;

max_area=max(area(high_dense_area));

tumor_label=find(area==max_area);

tumor=ismember (label, tumor_label);

if max_area>200
figure;
imshow(tumor)
title('tumoralone','FontSize',20);
else
h=msgbox('NoTumor!!','status');
%disp('notumor');
return;
end

%%Bounding box
box = stats(tumorlabel);

wantedBox=box.Bounding Box;

figure
imshow(inp);
title('BoundingBox','FontSize',20);

hold on;

rectangle ('Position',wanted Box,'EdgeColor','y');

hold off;

%%Getting Tumor Outline-image filling, eroding, subtracting
%erosion the walls by a few pixels

Dilation Amount = 5;

rad=floor(dilation Amount);
```

```
[r,c] = size(tumor);
filledImage=imfill(tumor,'holes');
for i=1:r
for j=1:c
x1=i-rad;
x2=i+rad;
y1=j-rad;
y2=j+rad;
if x1<1
x1=1;
end
if x2>r
x2=r;
end
if y1<1
y1=1;
end
if y2>c
y2=c;
end
eroded Image(i,j)=min(min(filled Image(x1:x2,y1:y2)));
end
end
figure
imshow(eroded Image);
title('erodedimage','FontSize',20);
%%subtracting eroded image from original BW image
Tumor Outline=tumor;
Tumor Outline(erodedImage)=0;
figure;
Imshow(tumorOutline);
title('Tumor Outline','FontSize',20);
%%Inserting the outline infiltrated image in red color
rgb = inp(:,:[1 1 1]);
```

```

red = rgb(:,:,1); red(tumor Outline)=255;
green = rgb(:,:,2);
green(tumor Outline)=0;
blue = rgb(:,:,3);
blue(tumor Outline)=0;
tumor Outline Inserted(:,:,1) = red;
tumor Outline Inserted(:,:,2) = green;
tumor Outline Inserted(:,:,3) = blue;
figure
imshow(tumor Outline Inserted);
title('Detected Tumor','FontSize',20);
%%Display Together
figure
subplot(231); imshow(s);title('Input image','FontSize',20);
subplot(232); imshow(inp);title('Filtered image','FontSize',20);
subplot(233); imshow(inp);title('Bounding Box','FontSize',20);
holdon; rectangle('Position',wanted Box,'EdgeColor','y');holdoff;
subplot(234);imshow(tumor);title('tumor alone','FontSize',20);
subplot(235);imshow(tumor Outline);title('Tumor Outline','FontSize',20);
subplot(236);imshow(tumor Outline Inserted);title('Detected Tumor','FontSize',20);

```

Input Images

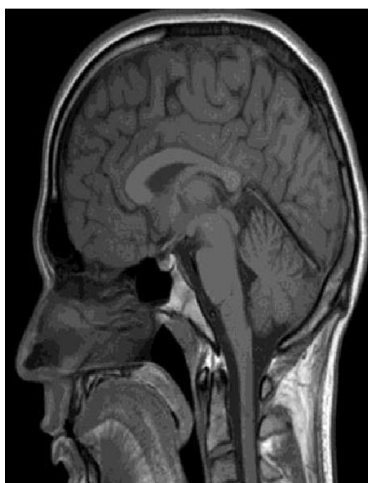


Figure.1



Figure. 2

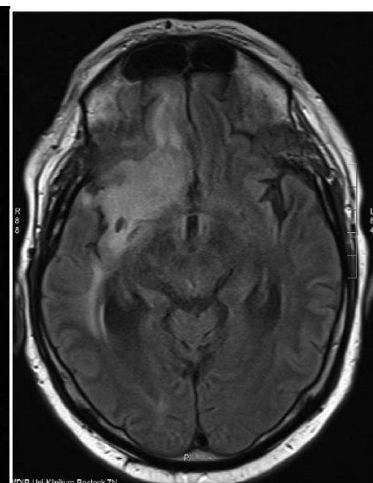
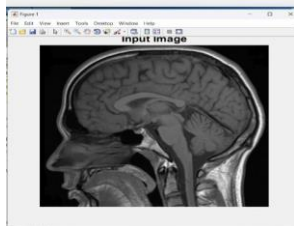


Figure.3

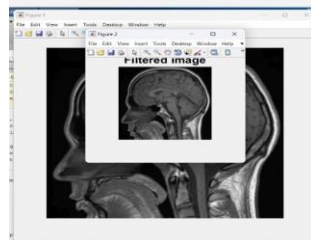
3. Results and Discussion

Output

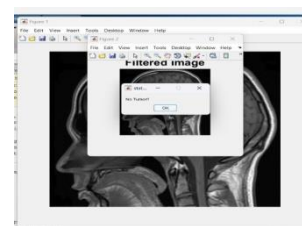
Input Image



Filtered Image



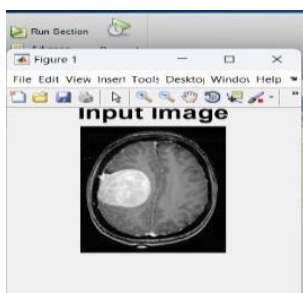
Detected Tumour



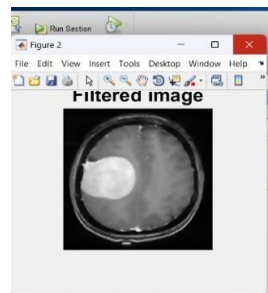
Output

Output for Image 2

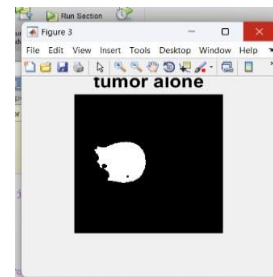
Input image



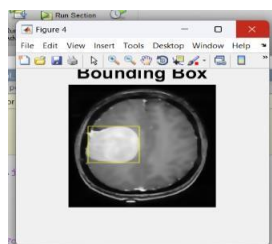
Filtered Image



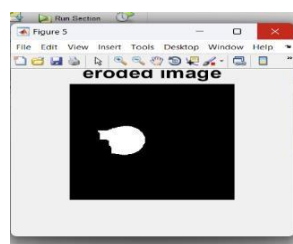
Tumour Alone



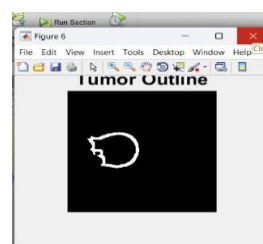
Bounding Box



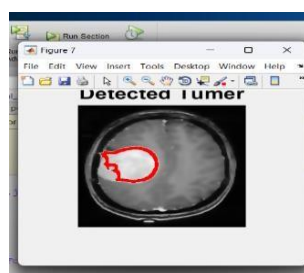
Eroded Image



Tumour Out line



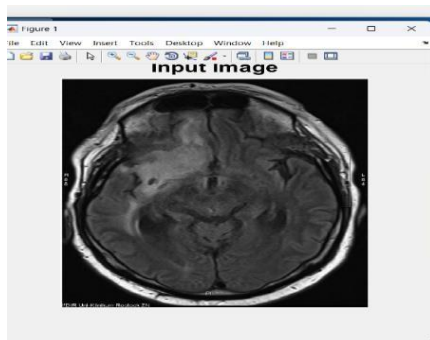
Detected Tumour



Output Image

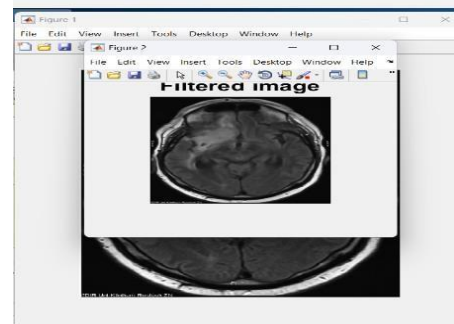


**Output for Image3
Input Image**



Tumour Detection

Filtered Image



No Tumour

4. Conclusion

Since brain tumours are a lethal form of cancer, early and precise identification is essential for effective therapy. Tumour detection by hand can be time-consuming and error-prone. This experiment suggests a technique for locating a tumour, if one is there, in a brain MRI scan. The image noise is removed using an isotropic filtering technique. It was chosen because it performs better than other techniques in maintaining features in non-linear images. For segmentation, an SVM classifier is suggested to identify the tumour. Morphological surgeries are carried out to locate the tumour precisely and mark its contour. The tumour, if any, can be precisely identified when this suggested methodology is used to an aberrant brain MRI scan.

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The Domination Uniform Subdivision Number of Total Graphs

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ABSTRACT

Let $G = (V, E)$ be a simple undirected graph. The domination uniform subdivision number $usd_\gamma(G)$ is the least positive integer k such that the subdivision of any k edges from G results in a graph having domination number greater than that of G . The total graph G^{+++} of G is a simple graph with vertex set $V(G) \cup E(G)$ in which adjacency is defined as follows: (a) two elements in $V(G^{+++})$ are adjacent if and only if they are adjacent in G (b) two elements in $E(G^{+++})$ are adjacent if and only if they are adjacent in G and (c) an element of $V(G)$ and an element of $E(G)$ are adjacent if and only if they are incident in G . In this paper, we investigate usd_γ of total graphs.

Keywords: Domination, Subdivision domination, Total graph and uniform subdivision domination

AMS Subject Classification: 05C69.

1 Introduction

Let $G = (V, E)$ be a simple undirected graph of order n and size m . If $v \in V(G)$, then the neighborhood of v is the set $N_G(v)$ (or $N(v)$) consisting of all vertices u which are adjacent to v . The closed neighborhood is $N_G[v] = N_G(v) \cup \{v\}$. The degree of v in G is $|N(v)|$ and is denoted by $\deg(v)$. The minimum degree of G is $\min \{\deg(v) : v \in V(G)\}$ and is denoted by $\delta(G)$. A vertex v is said to be pendant vertex if $\deg(v) = 1$. A path, a cycle and a complete graph on n vertices are denoted by P_n , C_n and K_n respectively. A graph is said to be connected if there exists a path between any pair of vertices. Otherwise it is said to be disconnected.

A subset D of $V(G)$ is said to be dominating set if every vertex of $V(G) - D$ is adjacent to at least one vertex in D . The minimum cardinality taken over all minimal dominating sets of G is the domination number of G and is denoted by $\gamma(G)$.

The domination subdivision number introduced by Arumugam, Velammalin [1] and several authors characterized trees according to their domination subdivision number. Also many results have also been obtained on the parameters sd_{dd} , $sd_{\gamma c}$ and $sd_{\gamma t}$. An edge $e = uv$ is said to be subdivided if it is deleted and replaced by a $u - v$ path of length two with a new

internal vertex w (*subdividing vertex*). $G \wedge \{e\}$ is the graph obtained by subdividing the edge e . A domination uniform subdivision number of G is the least positive integer k such that the sub division of any k edges from G results in a graph having domination number greater than that of G and is denoted by $usd_\gamma(G)$. If it does not exist, then $usd_\gamma(G) = 0$. This number was introduced and studied in [2].

A subset $S \subseteq E(G)$ is said to be domination subdivision stable set if $\gamma(G \wedge S) = \gamma(G)$. A domination subdivision stable set S is said to be maximal domination subdivision stable set if there is no domination subdivision stable set S' such that $|S'| > |S|$. $usd_\gamma(G) = |S| + 1$, where S is a maximum stable subdivision set of G . In [3] we have studied domination uniform subdivision number of $G \circ K_1$ for some standard graphs.

Wu and Meng [4] generalized the concept of total graphs to transformation graph G^{xyz} with $x, y, z \in \{+, -\}$ where G^{+++} is precisely the total graph of G , and G^{---} is the complement of G^{+++} . Each of these eight kinds of transformation graph G^{xyz} appears to have some nice properties; for instance, their diameters are small in most of the cases [4], and their edge connectives are equal to their minimum degree etc. [5]. In [6] the domination uniform subdivision number of G^{---} has been studied. Several authors discussed various concepts on transformation graphs [7, 8].

In this paper we study domination uniform subdivision number of G^{+++} . Terms not defined here are used in the sense of [9].

2 Results on connected graphs

In this section, we determine usd_γ of total graphs of some standard graphs. Also we investigate uniform subdivision domination number of total graph of connected graphs.

$$\textbf{Theorem 2.1} \text{ For a path on } n \text{ vertices } P_n, usd_\gamma(P_n^{+++}) = \begin{cases} 4 & \text{if } n \equiv 1(mod 5) \\ 3 & \text{if } n \equiv 2(mod 5) \\ 1 & \text{if } n \equiv 3(mod 5) \\ 3 & \text{if } n \equiv 4(mod 5) \\ 2 & \text{if } n \equiv 0(mod 5) \end{cases}$$

Proof: Let $v_1, v_2, \dots, v_n \in V(P_n)$, $e_1, e_2, \dots, e_{n-1} \in E(P_n)$ and $V(P_n^{+++}) = V(P_n) \cup E(P_n)$. In P_n^{+++} , $d_{P_n^{+++}}(v_1) = d_{P_n^{+++}}(v_n) = 2$, $d_{P_n^{+++}}(v_i) = 4$, $(2 \leq i \leq n - 1)$, $d_{P_n^{+++}}(e_i) = 4$, $(2 \leq i \leq n - 2)$ and $d_{P_n^{+++}}(e_1) = d_{P_n^{+++}}(e_{n-1}) = 3$. Here the minimum dominating set D of P_n^{+++} consists of both vertices and edges of P_n . To find the domination uniform subdivision number of P_n^{+++} , it is enough to construct the maximum domination subdivision stable set S . In order to construct S , we are going to form a

minimum dominating set D of P_n^{+++} . We shall start D with v_2 . The vertex v_2 is adjacent to v_1, v_3, e_1 and e_2 . Now choose a vertex e_i of P_n^{+++} which should not be adjacent to v_2 . Let us choose $e_4 \in D$, e_4 is adjacent to e_3, e_5, v_4 and v_5 . Again Choose a vertex v_j , which should not be adjacent to e_4 . Now we may choose $v_7 \in D$, v_7 is adjacent to v_6, v_8, e_6 and e_7 . Likewise continue the procedure to construct the minimum dominating set D of P_n^{+++} . For determining the maximum domination subdivision stable set, we consider the following cases.

Case(i): $n \equiv 1(mod 5)$

In this case we get three maximal domination subdivision stable sets.

If $v_n \in D$, $S_1 = \{v_n v_{n-1}, v_n e_{n-1}\}$, $|S_1| = 2$.

If $e_{n-1} \in D$, $S_2 = \{e_{n-1} e_{n-2}, e_{n-1} v_{n-1}\}$, $|S_2| = 2$.

If $v_{n-1} \in D$, $S_3 = \{v_{n-1} v_{n-2}, v_{n-1} e_{n-2}, v_{n-1} e_{n-1}\}$, $|S_3| = 3$.

From all the above cases S_3 is the maximum. Therefore, in this case $usd_\gamma(P_n^{+++}) = 4$.

Case(ii): $n \equiv 2(mod 5)$.

In this case also we have three possible cases.

If $v_n \in D$, $S_1 = \{\emptyset\}$, $|S_1| = 0$.

If $e_{n-1} \in D$, $S_2 = \{e_{n-1} e_{n-2}\}$, $|S_2| = 1$.

If $v_{n-1} \in D$, $S_3 = \{v_{n-1} v_{n-2}, v_{n-1} e_{n-2}\}$, $|S_3| = 2$.

From all the above cases, S_3 is the maximum. Therefore $usd_\gamma(P_n^{+++}) = 3$.

Case(iii): $n \equiv 3(mod 5)$.

There exists a unique minimal dominating set D and every $u \in V - D$ is adjacent to exactly one vertex v in D . And so the maximal domination subdivision stable set S is an empty set. Thus $usd_\gamma(P_n^{+++}) = 1$.

Case(iv): $n \equiv 4(mod 5)$

In this case we get three maximal domination subdivision stable sets.

If $v_n \in D$, $S_1 = \{v_n v_{n-1}\}$, $|S_1| = 1$.

If $e_{n-1} \in D$, $S_2 = \{e_{n-1} e_{n-2}, e_{n-1} v_{n-1}\}$, $|S_2| = 2$.

If $v_{n-1} \in D$, $S_3 = \{v_{n-1} v_{n-2}, v_{n-1} e_{n-2}\}$, $|S_3| = 2$.

From all the above cases, $usd_\gamma(P_n^{+++}) = 3$.

Case(v): $n \equiv 0(mod 5)$.

Here we have only two possible cases.

If $e_{n-1} \in D$, $S_1 = \{\emptyset\}$, $|S_2| = 0$.

If $v_{n-1} \in D$, $2 = \{v_{n-1} v_{n-2}\}$, $|S_2| = 1$.

From the above two cases, S_2 is the maximum. Therefore $usd_\gamma(P_n^{+++}) = 3$.

Hence the proof.

Theorem 2.2 For any cycle C_n , $usd_\gamma(C_n^{+++}) = \begin{cases} 4 & \text{if } n \equiv 1(mod 5) \\ 2 & \text{if } n \equiv 2(mod 5) \\ 5 & \text{if } n \equiv 3(mod 5) \\ 3 & \text{if } n \equiv 4(mod 5) \\ 1 & \text{if } n \equiv 0(mod 5) \end{cases}$.

Proof: Let $v_1, v_2, \dots, v_n \in V(C_n)$, $e_1, e_2, \dots, e_n \in E(C_n)$ and $V(C_n^{+++}) = V(C_n) \cup E(C_n)$. In C_n^{+++} , $d_{C_n^{+++}}(v_i) = d_{C_n^{+++}}(e_i) = 4$. Here the minimum dominating set D of C_n^{+++} consists of both vertices and edges of C_n . To find the domination uniform subdivision number of C_n^{+++} , it is enough to construct the maximal domination subdivision stable set S . In order to construct S , we are going to form a minimum dominating set D of C_n^{+++} . We shall start D with v_1 or e_1 . Without loss of generality, we may assume that $v_1 \in D$ and v_1 is adjacent to v_2, v_n, e_1 and e_n . Now choose $e_3 \in D$, e_3 is adjacent to e_2, e_4, v_3 and v_4 . Again Choose $v_6 \in D$ and so on. Proceeding in a similar way to construct the minimum dominating set D of C_n^{+++} . For determining the maximum domination subdivision stable set, we consider the following cases.

Case(i): $n \equiv 1(mod 5)$.

Now we have four maximal domination subdivision stable sets. They are:

If $v_n \in D$, $S_1 = \{v_n v_1, v_n e_n\}$, $|S_1| = 2$.

If $v_{n-1} \in D$, $S_2 = \{v_{n-1} v_{n-2}, v_{n-1} v_n, v_{n-1} e_{n-2}\}$, $|S_2| = 3$.

If $e_{n-1} \in D$, $S_3 = \{e_{n-1} e_{n-2}, e_{n-1} e_n, e_{n-1} v_n\}$, $|S_3| = 3$.

If $e_{n-2} \in D$, $S_4 = \{e_{n-2} v_{n-2}, e_{n-2} e_{n-3}\}$, $|S_4| = 2$.

From the above cases, $usd_\gamma(C_n^{+++}) = 3$.

Case(ii): $n \equiv 2(mod 5)$.

In this case, there will be at the most four vertices which are not get dominated by any of the vertices. They are v_{n-1} , v_{n-2} , e_{n-1} and e_{n-2} of C_n^{+++} . Here we have only two possible cases.

If $v_{n-1} \in D$, $S_1 = \{v_{n-1} v_n\}$, $|S_1| = 1$.

If $e_{n-2} \in D$, $S_2 = \{v_n v_{n-2}\}$, $|S_2| = 1$.

From the above two cases, $usd_\gamma(C_n^{+++}) = 3$.

Case (iii): $n \equiv 3(mod 5)$

In this case we have five maximal domination subdivision stable sets. They are :

If $v_n \in D$, $S_1 = \{v_n v_1, v_n v_{n-1}, v_n e_n\}$, $|S_1| = 3$.

If $v_{n-1} \in D$, $S_2 = \{v_{n-1} v_{n-2}, v_{n-1} v_n, v_{n-1} e_{n-2}\}$, $|S_2| = 3$.

If $e_n \in D$, $S_3 = \{e_n v_n, e_n v_1, e_n e_1\}$, $|S_3| = 3$.

If $e_{n-1} \in D$, $S_4 = \{e_{n-1} e_{n-2}, e_{n-1} e_n, e_{n-1} v_n, e_{n-1} v_{n-1}\}$, $|S_4| = 4$.

If $e_{n-2} \in D$, $S_5 = \{e_{n-2} e_{n-3}, e_{n-2} v_{n-2}, e_{n-2} v_{n-1}\}$, $|S_5| = 3$.

From all the above cases, S_4 is the maximum and hence $usd_\gamma(C_n^{+++}) = 5$.

Case(iv): $n \equiv 4(mod 5)$.

Here we have three possible cases.

If $v_n \in D$, $S_1 = \{v_n v_1, v_n e_n\}$, $|S_1| = 2$.

If $e_{n-1} \in D$, $S_2 = \{e_{n-1} e_n, e_{n-1} e_{n-2}\}$, $|S_2| = 2$.

If $v_{n-1} \in D$, $S_3 = \{v_{n-1} v_{n-2}, v_{n-1} e_{n-2}\}$, $|S_3| = 2$.

From all the above cases we conclude that $usd_\gamma(C_n^{+++}) = 3$.

Case(v): $n \equiv 0(mod 5)$.

There exists a unique minimal dominating set D and every $u \in V - D$ is adjacent to exactly one vertex v in D . And so the maximal domination subdivision stable set S is an empty set. Thus $usd_\gamma(C_n^{+++}) = 1$.

Theorem 2.3 For any star $K_{1,n}$, $usd_\gamma(K_{1,n}^{+++}) = 1$.

Proof: Let $v, v_1, v_2, \dots, v_n \in V(K_{1,n})$, where v be the full vertex of $K_{1,n}$ and $e_1, e_2, \dots, e_n \in E(K_{1,n})$. In $K_{1,n}^{+++}$, also v is the full vertex. Therefore $\gamma(K_{1,n}^{+++}) = 1$ and the maximal domination subdivision stable set S is an empty set. Thus $usd_\gamma(K_{1,n}^{+++}) = 1$.

3 Main results

Theorem 3.1 If G has a full vertex v , then $usd_\gamma(G^{+++}) = 1$ if and only if G is a star graph.

Proof: Let $v, v_1, v_2, \dots, v_{n-1} \in V(G)$ and v be the full vertex of G . Assume that G is a star. Then v is adjacent to all the vertices in G^{+++} . Therefore $\gamma(G^{+++}) = 1$ and $sousd_\gamma(G^{+++}) = 1$.

Conversely, assume that $usd_\gamma(G^{+++}) = 1$. Suppose G is not a star. Since v is adjacent to $e_i = v v_i (1 \leq i \leq n-1)$ and v_j in G , any minimum dominating set D of G^{+++} contains v, e_i or v_j .

Case(i): $v \in D$

Since G is not a star, there exists an edge e which is not incident with v . Then D contains a vertex of G^{+++} other than v . If it is a vertex u of G , then $N[u] \cap N[v] \neq \emptyset$ and so $usd_\gamma(G^{+++}) > 1$. If it is an edge e' , then $N[e'] \cap N[v] \neq \emptyset$ since the end vertices of e' are adjacent to v . Therefore, $usd_\gamma(G^{+++}) > 1$.

Case(ii): $e_i \in D$

Since e_i is adjacent to exactly two vertices of G , D contains atleast two vertices of G^{+++} . If $N[v] \cap N[u] \in V(G) - \{u\}$ is in D , then $N[u] \cap N[e_i] \neq \emptyset$ since u and e_i both are adjacent to v . If $e' \in V(G)$ is in D , then e' is adjacent to some e_j which is incident with v and so $N[e'] \cap N[e_j] \neq \emptyset$. Hence $usd_\gamma(G^{+++}) > 1$.

Case(iii): $v_j \in D$

If D contains any vertex u of G , then $N[u] \cap N[v_j] \neq \emptyset$ since v is adjacent to all the $n - 1$ vertices. If $e_k = vv_k \in D$, then $N[v_j] \cap N[e_k] \supseteq \{v\}$ and so $usd_\gamma(G^{+++}) > 1$. Let us take D contains $e' = v_i v_r \in E(G)$. If $j = i$ or $j = r$, then $N[v_j] \cap N[e'] \neq \emptyset$ and so $usd_\gamma(G^{+++}) > 1$. Otherwise, v_j is not incident with e' . Also both are not adjacent to a common vertex of G^{+++} . Suppose any other edge $e^* = v_r v_s \in D$. Then e^*, e' and v_j are independent. Thus $\langle V(G) - \{v\} \rangle \cong K_1 \cup kK_2$ and hence $usd_\gamma(G^{+++}) = 1$, we get a contradiction.

Theorem 3.2 Let G be a connected graph. If $\Delta(G) = n - 2$, then $usd_\gamma(G^{+++}) \leq \frac{1}{2}(n + 2)(n - 3)$.

Proof: Let G be a connected graph and let $deg(v) = \Delta(G)$. Then there exists $u \in V(G)$ such that u is the only vertex which is non-adjacent to v . Since G is connected, $N[u] \cap N[v] \neq \emptyset$.

Case(i): $N[u] = N[v]$

If $\langle V - \{u, v\} \rangle$ is totally disconnected, then the set S of all edges from v to $N[v]$ from a maximum domination subdivision stable set of G^{+++} and $|S| = n - 2$. Hence $usd_\gamma(G^{+++}) = n - 1$.

If $\langle V - \{u, v\} \rangle$ has atleast one edge, then $D = \{u, v\}$ can not be a dominating set of G^{+++} . If all the edges of $\langle V - \{u, v\} \rangle$ are adjacent, then $\{ue_j', v\}$ and $\{ve_j, u\}$ are minimum

dominating sets of G^{+++} . Then maximum domination subdivision stable set S of G^{+++} has only one edge of G^{+++} . Therefore $usd_\gamma(G^{+++}) = 2$.

If $\langle V - \{u, v\} \rangle$ has atleast two independent edges then any maximum domination subdivision stable set S has atleast $n - 3$ edges.

If $\langle V - \{u, v\} \rangle$ is complete graph, then $N[v]$ is a dominating set of G^{+++} . Then $S = \{v_i e / e \in E(\langle V - \{u, v\} \rangle) \text{ and no two edges are same} \} \cup \{vv_i / v_i \in N[v] \text{ and except one } v_j\} \cup \{uv_i / v_i \in N[v] \text{ and except one } v_j\}$ is a maximum domination subdivision stable set of G^{+++} and $|S| = \frac{(n-2)(n-3)}{2} + 2(n-3) = \frac{1}{2}(n+2)(n-3)$.

Case(ii) $N[u] \neq N[v]$

In this case, any maximum domination subdivision stable set S has less number edges as in case(i). Hence $|S| < \frac{1}{2}(n+2)(n-3)$.

4 Results on disconnected graphs

Theorem 4.1 Let G be a disconnected graph with k components G_1, G_2, \dots, G_k . $usd_\gamma(G^{+++}) = usd_\gamma(G_1^{+++}) + usd_\gamma(G_2^{+++}) + \dots + usd_\gamma(G_k^{+++})$.

Proof: Since G is a disconnected graph with k components, G^{+++} is also a disconnected graph with k components. We have, $usd_\gamma(G^{+++}) = usd_\gamma(G_1^{+++}) + usd_\gamma(G_2^{+++}) + \dots + usd_\gamma(G_k^{+++})$. Hence the result.

Corollary 4.2 If any graph $G \cong K_{1,n_1} \cup K_{1,n_2} \cup \dots \cup K_{1,n_k}$, then $usd_\gamma(G^{+++}) = k$.

Proof: Assume a disconnected graph G with n components $G \cong K_{1,n_1} \cup K_{1,n_2} \cup \dots \cup K_{1,n_k}$. By theorem 4.1, $usd_\gamma(G^{+++}) = usd_\gamma(K_{1,n_1}) + usd_\gamma(K_{1,n_2}) + \dots + usd_\gamma(K_{1,n_k})$.

By theorem 2.3, $usd_\gamma(G^{+++}) = 1 + 1 + \dots + 1$ (k times).

Hence $usd_\gamma(G^{+++}) = k$.

Theorem 4.3 $usd_\gamma(G^{+++}) = 0$ iff G is an empty graph.

Proof: Assume that G is an empty graph. Then G^{+++} has no edges and so $usd_\gamma(G^{+++}) = 0$.

Conversely assume that $usd_\gamma(G^{+++}) = 0$. Suppose that G is not empty then there exists atleast one edge in G . Then G^{+++} has a non-empty component G^* with atleast three vertices. Thus $usd_\gamma(G^*) \geq 1$ and so $usd_\gamma(G^{+++}) \geq 1$ (by theorem 3.1). This contradicts our assumption. Hence G is non-empty.

Conclusion

In this article, the exact value of $usd_\gamma(G^{+++})$ for some standard graphs are determined. Also, for a graph with $\Delta(G) = n - 1$, we prove that $usd_\gamma(G^{+++}) = 1$ if and only if G is a star. Further, we obtain few results on disconnected graphs.

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An Optimal Solution of a Fuzzy Linear Programming Problem

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ABSTRACT

The main aspect of this paper is to find the optimal solution of a fuzzy linear programming problem. Where fuzzy quantities are in the form of triangular fuzzy numbers. The triangular fuzzy number is converted into a crisp value using a novel suggested ranking method. The fuzzy simplex method is then applied to obtain the optimal solution.

Keywords: A novel suggested ranking method, Fuzzy linear programming problem, Optimal solution, Triangular fuzzy number.

1. Introduction

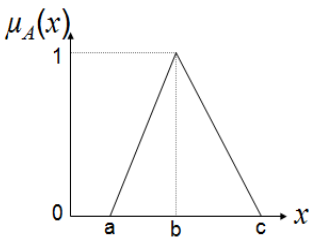
Bellman and Zadeh proposed the concept of decision-making in a Fuzzy environment [1]. After this pioneering work, several authors used this concept for solving fuzzy linear programming problems [2], [3], [4], [5], [6], [7], [8]. A fuzzy linear programming problem (FLPP) is an extension of conventional linear programming that accommodates uncertainty and imprecision in the problem's coefficients and constraints. In traditional linear programming, all parameters are assumed to be precise and deterministic, but in real-world scenarios, various factors may involve vagueness or ambiguity. In FLPP, decision variables, coefficients, and constraints can be described using fuzzy sets, which provide a more flexible framework for modeling the inherent uncertainty in decision-making. The objective is to optimize a fuzzy objective function subjected to fuzzy constraints. The application of FLPP is diverse, ranging from supply chain management and finance to engineering and project planning. By considering fuzzy parameters, FLPP enables a more realistic representation of complex systems.

The outline of this work is described below. In section 2: Basic Definitions, Proposed ranking technique. In section 3: Theorems on a fuzzy linear programming problem. In section 4: Procedure for solving a fuzzy linear programming problem. In section 5: Numerical example. Finally, a conclusion in section 6.

2. Preliminaries

Definition

For a triangular fuzzy number A it can be represented by $A = (a, b, c)$ with membership function $\mu(x)$ given by

$$\mu_A(x) = \begin{cases} 0 & \text{if } x \leq a \\ \frac{x-a}{b-a} & \text{if } a \leq x \leq b \\ \frac{c-x}{c-b} & \text{if } b \leq x \leq c \\ 0 & \text{if } x \geq c \end{cases}$$


$$\mu_A(x) = \begin{cases} \frac{x-a}{b-a}, & a \leq x \leq b \\ 1, & x = b \\ \frac{c-x}{c-b}, & b \leq x \leq c \\ 0, & \text{otherwise} \end{cases}$$

The Arithmetic Operations on Fuzzy Numbers

Let $A_1 = (a, b, c)$ and $A_2 = (d, e, f)$ be two non-negative triangular fuzzy numbers then

- (i) $A_1 \oplus A_2 = (a, b, c) \oplus (d, e, f) = (a + d, b + e, c + f)$
- (ii) $A_1 - A_2 = (a, b, c) - (d, e, f) = (a - f, b - e, c - d)$
- (iii) $-A_1 = -(a, b, c) = (-c, -b, -a)$
- (iv) $A_1 \otimes A_2 = (a, b, c) \otimes (e, f, g) = (ae, bf, cg)$

Ranking function

Ranking fuzzy numbers are an important aspect of decision-making in a fuzzy environment. Since 1965, many authors have proposed different methods for ranking fuzzy numbers.

Proposed Ranking Technique

This paper proposes a method that ranks triangular fuzzy numbers which is simple in calculation.

If a fuzzy number (a, b, c) is a triangular fuzzy, then new ranking function is defined as,

$$\int_0^1 [\gcd(a, c)b\alpha] d\alpha$$

Mathematical Formulation of Fuzzy Linear Programming Problem

$$\text{Maximize/Minimize } z = \sum_{j=1}^n c'_j x'_j \text{ subject to}$$

$$\sum_{j=1}^n a'_{ij} x'_j (\leq = \geq) b'_i ; i = 1, 2, \dots, m$$

Here c'_j, a'_{ij}, b'_i are fuzzy numbers, x'_j is a non – negative fuzzy number $j = 1, 2, \dots, n$.

3. Theorems on Fuzzy Linear Programming Problem

Theorem 3.1

The set of all feasible solutions of a fuzzy linear programming problem is a convex set.

Proof:

Consider a FLPP in standard form,

$$\text{Maximize } z = c'x' \text{ subject to}$$

$$A'x' = b'$$

$$x' \geq 0$$

x' is a $n \times 1$ matrix, c' is a $(1 \times n)$ matrix and A' is a $(m \times n)$ matrix. The values in these matrices are fuzzy numbers.

Let F be the set of all feasible solutions of the above FLPP.

Let $k'_1, k'_2 \in F$ and $0 \leq \sigma \leq 1$

Since $k'_1, k'_2 \in F$ we have

$$A'k'_1 = b' \text{ and } k'_1 \geq 0$$

$$A'k'_2 = b' \text{ and } k'_2 \geq 0$$

$$\begin{aligned} \text{Now, } A'[\sigma k'_1 + (1 - \sigma)k'_2] &= A'\sigma k'_1 + A'(1 - \sigma)k'_2 \\ &= \sigma A'k'_1 + (1 - \sigma)A'k'_2 \\ &= \sigma b' + (1 - \sigma)b' \\ &= b' \end{aligned}$$

$\therefore \sigma k'_1 + (1 - \sigma)k'_2$ is a solution of FLPP

Now, since $k'_1 \geq 0, k'_2 \geq 0$ and $0 \leq \sigma \leq 1$

we have $\sigma k'_1 + (1 - \sigma)k'_2 \geq 0$.

Hence $\sigma k'_1 + (1 - \sigma)k'_2$ is a feasible solution for the FLPP.

$$\therefore \sigma k'_1 + (1 - \sigma)k'_2 \in F$$

Theorem 3.2

Let $k^{(1)}, k^{(2)}, \dots, k^{(n)}$ be optimal solutions of the FLPP. Then any convex combination of $k^{(1)}, k^{(2)}, \dots, k^{(n)}$ is also an optimal solution of the FLPP.

Proof:

Since $k^{(1)}, k^{(2)}, \dots, k^{(n)}$ are optimal solutions of the FLPP, we have

$$z = c'k^{(1)} = c'k^{(2)} = \dots = c'k^{(n)}$$

Let k be the convex combinations of $k^{(1)}, k^{(2)}, \dots, k^{(n)}$.

$$k = \sigma_1 k^{(1)} + \sigma_2 k^{(2)} + \dots + \sigma_n k^{(n)}$$

where $0 < \sigma_i < 1$ and $\sum_{i=1}^n \sigma_i = 1$

$$c'k = c'[\sigma_1 k^{(1)} + \sigma_2 k^{(2)} + \dots + \sigma_n k^{(n)}]$$

$$= \sigma_1 c'k^{(1)} + \sigma_2 c'k^{(2)} + \dots + \sigma_n c'k^{(n)}$$

$$= \sigma_1 z + \sigma_2 z + \dots + \sigma_n z$$

$$= (\sigma_1 + \sigma_2 + \dots + \sigma_n)z$$

$$c'k = z$$

Theorem 3.3

If a FLPP has more than one optimal solution, then it has an infinite number of optimal solutions.

Proof:

Let us consider two different optimal solutions of FLPP k_1 and k_2 .

Consider the convex combination of k_1 and k_2 as $\sigma k_1 + (1 - \sigma)k_2$, $0 < \sigma < 1$

According to the above result, any convex combination is also an optimal solution for FLPP.

$\therefore \sigma k_1 + (1 - \sigma)k_2$ is also an optimal solution of FLPP.

Since σ can take any value between 0 and 1. There are infinitely many points for σ .

\therefore Each corresponds to an optimal solution.

\therefore FLPP has an infinite number of optimal solutions

4. Fuzzy Simplex Procedure

The procedure of Fuzzy Simplex Method

Step-1: In a Fuzzy linear programming problem, convert fuzzy values to crisp values using the proposed ranking technique.

Step-2: Express the LPP in the standard form by introducing the slack/surplus variables in each of the constraints.

Step-3: Obtain an initial basic feasible solution and compute net evaluation

$$z_j - c_j = \sum_{i=1}^m c_{B_i} a_{ij} - c_j \text{ where } j = 1, 2, \dots, m + n$$

- (i) If all net evaluations are non-negative, then the initial basic feasible solution is an optimal solution.
- (ii) If at least one net evaluation is negative, proceed to next step.

Step-4: Choose the most negative of net evaluation. The corresponding column is the entering column. If all values in the column are less than zero, then problem has unbounded solution

Step-5: Compute the ratio (X_B /Entering column) and choose the minimum of these ratio. The corresponding row is the leaving row. The intersection of entering column and leaving row is called key element.

Step-6: Convert the key element to unity by dividing its row by key element and all other elements in remaining rows by using elementary row transformations.

Step-7: Go to step-3 and repeat the procedure until an optimal solution is obtained or there is an indication of an unbounded solution.

5. Numerical Example [9]

Example:1

Let us solve the following FLLP with fuzzy constraints.

$$\text{Maximize } z = (1, 6, 9) x_1 + (2, 3, 8) x_2 \text{ subject to}$$

$$(2, 3, 4) x_1 + (1, 2, 3) x_2 \leq (6, 16, 30)$$

$$(-1, 1, 2) x_1 + (1, 3, 4) x_2 \leq (1, 17, 30)$$

$$x_{1,2} \geq 0$$

Applying the proposed ranking technique, we get

$$\text{Maximize } z = 3x_1 + 3x_2 \text{ subject to}$$

$$3x_1 + x_2 \leq 48$$

$$0.5x_1 + 1.5x_2 \leq 8.5$$

$$x_{1,2} \geq 0$$

Standard form,

We introduce two slack variables $s_1 \geq 0$ and $s_2 \geq 0$

$$\text{Maximize } z = 3x_1 + 3x_2 + 0s_1 + 0s_2 \text{ subject to}$$

$$3x_1 + x_2 + s_1 = 48$$

$$0.5x_1 + 1.5x_2 + s_2 = 8.5$$

$$x_1, x_2, s_1, s_2 \geq 0$$

Table 5.1

Basis		C_j	3	3	0	0	End of the simplex procedure
C_B	B	X_B	x_1	x_2	s_1	s_2	
3	x_1	15.879	1	0	0.3747	-0.2498	
3	x_2	0.363	0	1	-0.125	0.7502	
Optimality is attained		$z_j = 48.726$	3	3	0.7491	1.5012	
		$z_j - C_j$	0	0	0.7491	1.5012	

Now, all the $z_j - C_j \geq 0$. Hence optimality is reached and the optimal solution is $x_1 = 15.879$, $x_2 = 0.363$ and the maximum value of $z = 48.726$.

Example:2

Let us solve the following FLLP with fuzzy constraints.

$$\text{Maximize } z = (1, 2, 3) x_1 + (2, 3, 4) x_2 \text{ subject to}$$

$$(0, 1, 2) x_1 + (1, 2, 3) x_2 \leq (2, 10, 24)$$

$$(1, 2, 3) x_1 + (0, 1, 2) x_2 \leq (1, 8, 21)$$

$$x_1, x_2 \geq 0$$

Applying the proposed ranking technique, we get

$$\text{Maximize } z = x_1 + 3x_2 \text{ subject to}$$

$$x_1 + x_2 \leq 10$$

$$x_1 + x_2 \leq 4$$

$$x_1, x_2 \geq 0$$

Standard form,

We introduce two slack variables $s_1 \geq 0$ and $s_2 \geq 0$

$$\text{Maximize } z = x_1 + 3x_2 + 0s_1 + 0s_2 \quad \text{subject to}$$

$$x_1 + x_2 + s_1 = 10$$

$$x_1 + x_2 + s_2 = 4$$

$$x_1, x_2 \geq 0$$

Table 5.2

Basis		C_j	1	3	0	0	End of thesimplexpr ocedure
c_B	B	X_B	x_1	x_2	s_1	s_2	
0	s_1	6	0	0	1	-1	
3	x_2	4	1	1	0	1	
Optimality isattained		$z_j=12$	3	3	0	3	
		$z_j - c_j$	2	0	0	3	

Now, all the $z_j - c_j \geq 0$. Hence optimality is reached and the optimal solution is $x_1=0, x_2=4$ and the maximum value of $z=12$

Applications: [10]

Fuzzy linear programming (FLP) finds versatile applications in various domains, including supply chain management, project management, energy management, air pollution management, and marketing. In supply chain management, FLP accommodates uncertainties related to demand, lead times, and resource availability, optimizing inventory levels and distribution strategies. In project management, it addresses the imprecise nature of task durations and resource constraints, enhancing project scheduling and resource allocation. Energy management benefits from FLP by handling uncertainties in energy demand and supply, contributing to efficient resource utilization. In air pollution management, FLP aids in decision-making by considering fuzzy environmental factors and regulatory constraints, supporting effective pollution control measures. Additionally, FLP plays a crucial role in marketing, where it assists in decision-making processes involving vague market trends, consumer preferences, and advertising effectiveness, leading to more robust marketing strategies. Overall, the application of FLP in these diverse areas reflects its ability to model and optimize complex systems under uncertainty.

6. Conclusion

In this paper, we considered numerical examples with values as triangular fuzzy numbers. Then they were transformed into crisp values using a novel suggested ranking technique. The solution is obtained by the fuzzy simplex method and found the optimal solution. The proposed ranking technique discussed here is very simple, easy to implement, and to apply for solving realistic decision-making problems in areas like management

science, engineering, operations research, and other decision-making subjects involving fuzzy parameters. Their applications highlighted the future potential of these techniques in tackling even more complex decision-making challenges.

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Relatively Prime Domination in Discrete and Ascending Topological Graphs

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ABSTRACT

Let (X, τ) be a topological space. The graph $G_\tau = (V, E)$ is called a topological graph if $V = \{u: u \in \tau, u \neq \emptyset, X\}$ and $E = \{uv \in E(G_\tau) \text{ if } u \cap v \neq \emptyset, u \neq v \text{ and } u, v \in \tau\}$. In this paper, we explore the relatively prime domination number in discrete topological graphs and ascending topological graphs. Additionally, we investigate the relatively prime domination number in the context of switching between discrete and ascending topological graphs, as well as in modified graphs resulting from the deletion or addition of vertices in both discrete and ascending topological graphs.

Keywords: Domination, Reconstruction.

1. Introduction

Atopology [1] on a non-empty set X is a collection τ of subsets of X having the following properties: \emptyset and X are in τ ; the union of the elements of any sub collection of τ is in τ ; the intersection of the elements of any finite sub-collection of τ is in τ and A set X for which a topology τ has been specified is called a topological space. That is, a topological space is an ordered pair (X, τ) consisting of a set X and a topology τ on X . If τ consists the collection of all subsets of X is called the discrete topology and the collection consisting of X and \emptyset is called the indiscrete topology or the trivial topology. A graph G consists of a non-empty finite set $V(G)$ of elements called vertices and a finite set $E(G)$ of distinct unordered pairs of distinct elements of $V(G)$ called edges. The graph $G_\tau = (V, E)$ is called a topological graph if $V = \{u: u \in \tau, u \neq \emptyset, X\}$ and $E = \{uv \in E(G_\tau) \text{ if } u \cap v \neq \emptyset, u \neq v \text{ and } u, v \in \tau\}$.

Researchers Ali Ameer Jabor and Ahmed Abd-Ali Omran explored the properties of discrete topological spaces, establishing that the domination number for a discrete topological graph is 2. They also delved into affection domination by manipulating edges or vertices in a Discrete Topological Graph. In our study, we have presented findings on the relatively prime domination number for discrete topological graphs and ascending topological graphs, demonstrating that it is zero. Additionally, we have discussed the concept of relatively prime

domination for switching graphs and modified graphs obtained by deleting or adding edges or vertices.

2. Basic Definitions

Definition 1 [3] Deleting the Vertex: If v is a vertex of a graph G , we denote by $G - v$ the graph obtained from G by deleting the vertex v together with the edges incident on v .

Definition 2 [3] Deleting the Edge: If e is an edge of a graph G , we denote $G - e$ the graph obtained from G by deleting the edge e .

Definition 3 [4] Dominating Set: A subset S of V is said to be dominating set in G if every vertex in $V - S$ is adjacent to at least one vertex in S .

Definition 4 [4] Domination Number: The domination number $\gamma(G)$ is the minimum cardinality taken over all dominating set of G .

Definition 5 [5] Relatively Prime Dominating Set: Let G be a non-trivial graph. A set $S \subseteq V$ is said to be relatively prime dominating set if it is a dominating set with at least two elements and for every pair of vertices u and v in S such that $(\deg(u), \deg(v)) = 1$.

Definition 6 [5] Relatively prime Domination Number: The minimum cardinality taken over all relatively prime dominating set is called relatively prime domination number and it is denoted by $\gamma_{rpd}(G)$. If there is no such pair exist, then $\gamma_{rpd}(G) = 0$.

Definition 7 [5] Switching in Graphs: For a finite undirected graph $G(V, E)$ and a subset $\sigma \subseteq V$, the switching of G by σ is defined as the graph $G^\sigma(V, E')$ which is obtained from G by removing all edges between σ and $V - \sigma$. For $\sigma = \{v\}$, we write G^v instead of $G^{\{v\}}$ and the corresponding switching is called as vertex switching

3. Degree of each vertex in the Discrete Topological Graph

Let (X, τ) be the discrete topological space with $|X| \geq 3$ and G_τ be the discrete topological graph. In order to find the relatively prime domination number, we need to find the degree of each element.

Consider the discrete topological space with five elements.

Let $X = \{a, b, c, d, e\}$ and so $|\tau_X| = 2^5 = 32$.

Now by the definition of topological graph $|V(G_\tau)| = 30$.

First we find the degree of the element of order 4.

For that, first we find the number of elements which are non-adjacent to it.

Let us represent the five elements in the set X as $1+1+1+1+1$.

Here, the first four one represents the chosen element of order 4.

Remaining only one 1's is left.

This shows that, there is a possible element of order 4, 3, 2 such that their intersection with the chosen element is nonempty.

Thus, the only possible element is of order 1.

Thus, number of elements of order 1 which are non-adjacent to the chosen element = $1 C_1 = 1$

Therefore, number of elements non-adjacent to chosen element = 1

Hence degree of element of order 4 = $2^n - 2 - 1 - 1 = 2^n - 2^1 - 2$

Next, we find out the degree of an element of order 3.

Let the element be U . As before, 1+1+1+1+1 represent the five elements in the set X and the first three elements in U .

Remaining two 1's is left.

This shows that there are no possible elements of order 4, 3 such that intersection with U is non-empty.

Therefore, the only possible elements are of order 1 and 2

Now, number of elements of order 2 which are non-adjacent to $U = 2 C_2 = 1$

Number of elements of order 1 which are non-adjacent to $U = 2 C_1 = 2$

Therefore, number of elements non-adjacent to $U = 1 + 2 = 3$

Hence degree of $U = 2^5 - 2 - 3 - 1 = 2^5 - 2 - 4 = 2^5 - 2 - 2^2 = 2^5 - 2^2 - 2$

Next, we find the degree of an elements of order 2.

Let the element be U .

The first two 1's represent the elements in the set U .

Remaining three 1's is left.

Thus, there is no possible element of order 3 such that their intersection with U is non-empty.

Therefore, the only possible elements of order which are non-adjacent to U is 1, 2, 3

Number of elements of order 3 which are non-adjacent to $U = 3 C_3 = 1$

Number of elements of order 2 which are non-adjacent to $U = 3 C_2 = 3$

Number of elements of order 1 which are non-adjacent to $U = 3 C_1 = 3$

Therefore, number of elements which are non-adjacent to $U = 1 + 3 + 3 = 7$

Degree of $U = 2^5 - 2 - 8 = 2^5 - 2^3 - 2$

Finally, we find out the Degree of elements of order 1.

Let the elements be U .

Remaining four 1's is left.

Hence the possible element of order which are non-adjacent to U is 4,3,2,1.

Number of elements of order 4 which are non-adjacent to $U = 4C_4 = 1$

Number of elements of order 3 which are non-adjacent to $U = 4C_3 = 4$

Number of elements of order 2 which are non-adjacent to $U = 4C_2 = 6$

Number of elements of order 1 which are non-adjacent to $U = 4C_1 = 4$

Number of elements which are non-adjacent to $U = 1+4+6+4 = 15$

Therefore, degree of $U = 2^5 - 2 - 16 = 2^5 - 2^4 - 2$

Hence degree of an element of order 4 $= 2^5 - 2^{5-4} - 2 = 2^5 - 2^1 - 2$

Degree of an element of order 3 $= 2^5 - 2^{5-3} - 2 = 2^5 - 2^2 - 2$

Degree of an element of order 2 $= 2^5 - 2^{5-2} - 2 = 2^5 - 2^3 - 2$

Degree of an element of order 1 $= 2^5 - 2^{5-1} - 2 = 2^5 - 2^4 - 2$

In general, let X be a topological space of order $n, n \geq 3$ and G_τ be the discrete topological graph.

Then, the degree of an element of order 1 $= 2^n - 2^{n-1} - 2$

Degree of an element of order 2 $= 2^n - 2^{n-2} - 2$

Degree of an element of order 3 $= 2^n - 2^{n-3} - 2$

.....

Degree of an element of order $n-2 = 2^n - 2^2 - 2$

Degree of an element of order $n-1 = 2^n - 2 - 2$

Note: Here the degree of each element in the discrete topological graph is even.

4. Relatively Prime Domination Number

Throughout this section, n denotes the number of elements in X ; p denotes the number of vertices in the graph G_τ ; r denotes the order of an open set.

Theorem 4.1. Let (X, τ) be the discrete topological space with $|X| \geq 3$. Then the relatively prime domination number of discrete topological graph is $\gamma_{rpd}(G_\tau) = 0$.

Proof: Let (X, τ) be the discrete topological space with $|X| \geq 3$ and G_τ be the discrete topological graph. By above note, degree of each vertex in G_τ is even. Therefore, relatively prime dominating set does not exist for discrete topological graph and hence $\gamma_{rpd}(G_\tau) = 0$.

Remark: As relatively prime dominating set does not exist for discrete topological graph; we find the relatively prime domination number for switching graph of Discrete

Topological Graph.

Theorem 4.2. Let (X, τ) be the discrete topological space of order $n, n \geq 3$. hen

$$\gamma_{rpd}(G_\tau^U) = \begin{cases} 2 & \text{if } (\deg U, \deg V) = 1, V \in V(G_\tau^U), U \subseteq V, \deg(U) + \deg(V) \geq p - 1 \\ 0 & \text{Otherwise} \end{cases}$$

Proof: Let (X, τ) be the discrete topological space and G_τ be the discrete topological graph. We proceed by two cases.

Case 1: U be the vertex of order $r, 1 \leq r \leq n - 2, n = |X|$.

In the resulting graph G_τ^U , degree of U is odd. Now, we choose an element in $V(G_\tau^U)$, say V such that V contains the vertex U and $\deg(U) + \deg(V) \geq p - 1$. If $(\deg U, \deg V) = 1$, then relatively prime dominating set = $\{U, V\}$ and the relatively prime domination number is 2. If no such vertex exist in $V(G_\tau^U)$, then the relatively prime dominating set does not exist, as we cannot choose an element V in $V(G_\tau^U)$ with order V less than order of U , because $\deg(U) + \deg(V) < p - 1$. Therefore, $\gamma_{rpd}(G_\tau^U) = 0$ in this case.

Case 2: U be the vertex of order $n - 2$.

In the resulting graph G_τ^U , degree of U is one. Now choose an element, say V in $V(G_\tau^U)$, of order $n - 2$. (If we choose an element of order less than $n - 2$ in $V(G_\tau^U)$, then $\deg(U) + \deg(V) < p - 1$). Since $\deg(U) = 1$, let the element be $\{a\}$. Since $\deg(V) = p - 2$, and it contains the element $\{a\}$, we still left with an element to cover, say $\{b\}$. In order to cover $\{b\}$, we must choose an element contains $\{b\}$. As degree of all other elements except U has degree even, the relatively prime dominating set does not exist. Therefore, $\gamma_{rpd}(G_\tau^U) = 0$ in this case.

Thus,

$$\gamma_{rpd}(G_\tau^U) = \begin{cases} 2 & \text{if } (\deg U, \deg V) = 1, V \in V(G_\tau^U) \text{ and } U \subseteq V, \deg(U) + \deg(V) \geq p - 1 \\ 0 & \text{Otherwise} \end{cases}$$

Theorem 4.3. Let (X, τ) be the topological space with $|X| \geq 3$. Then

$$\gamma_{rpd}(G_\tau - e) = \begin{cases} 2 & \text{if } (\deg U, 2^n - 4) = 1, \text{ where } e \text{ is incident with the vertex } U \\ 0 & \text{Otherwise} \end{cases}.$$

Proof: Let (X, τ) be the topological space with $n \geq 3$ where $n = |X|$ and G_τ be the discrete topological graph. Let e be the edge removed from G_τ . Then degree of two elements say U and V which incident with the edge e is $\deg(U) - 1, \deg(V) - 1$. Therefore, $\deg(U) - 1 = \deg(V) - 1 = \text{odd}$. Since the vertices of order $n - 1$ covers $p - 1$ vertices, we take such a vertex say W .

Since $\deg(V) = \text{odd}$ and if $(\deg(U), \deg(W)) = (\deg(U), 2^n - 4) = 1$, relatively prime dominating set $\{U, W\}$ and hence $\gamma_{rpd}(G_\tau^U) = 2$. If $(\deg(U), \deg(W)) \neq 1$, then relatively prime dominating set does not exist and so $\gamma_{rpd}(G_\tau - e) = 0$.

Theorem 4.4. Let (X, τ) be the discrete topological space with $|X| \geq 3$. Then

$$\gamma_{rpd}(G_\tau - v) = \begin{cases} 2 & \text{if } (\deg U, 2^n - 4) = 1, \text{ where } e \text{ is incident with the vertex } U \\ 0 & \text{Otherwise} \end{cases}$$

Proof: Let (X, τ) be the discrete topological space with $n \geq 3$ where $n = |X|$ and G_τ be the discrete topological graph. Consider the graph $G_\tau - v$. Here the vertices which are adjacent with the vertex v has odd degree. Denote the vertices which have odd degree by $U_i, i = 1, 2, \dots, n - 2$. Note that U_i is a vertex of order i in G_τ . Now, choose a vertex, say W of degree $p - 1$. If $(\deg(U_i), \deg(W)) = 1$, for some U_i , then the relatively prime dominating set is $\{U, W\}$ and hence $\gamma_{rpd}(G_\tau^U) = 2$. If $(\deg(U), \deg(W)) \neq 1$, for all U_i , then relatively prime dominating set does not exist.

Theorem 4.5. Let (X, τ) be the topological space with $|X| \geq 3$. Then

$$\gamma_{rpd}(G + e) = \begin{cases} 2 & \text{if } (\deg U, 2^n - 4) = 1, \text{ where } e \text{ is incident with the vertex } U \\ 0 & \text{Otherwise} \end{cases}$$

Proof: Let (X, τ) be the topological space with $n \geq 3$ where $n = |X|$ and G_τ be the discrete topological graph. Let e be the new edge added in G_τ . Then degree of two elements say U and V which are incident with the edge e is $\deg(U) + 1, \deg(V) + 1$, which is odd. Now if $(p - 1, \deg(U) + 1) = 1$, then the relatively prime dominating set exist and $\gamma_{rpd}(G_\tau + e) = 2$. Otherwise, the relatively prime dominating set does not exist.

5. Relatively Prime Domination on Ascending Topological Graph

In this section, we have discussed about the properties and domination, relatively prime domination number of Ascending Topological Graph. A topological space X is said to have an ascending chain if every open sets of X forms an ascending chain. A topological space which have an ascending chain is called as Ascending Topological Space.

Let (X, τ) be a topological space with $|X| \geq 3$ having ascending chain. Let G_τ be the corresponding topological graph. Since the open sets in τ are in ascending chain, the intersection between any two non-empty open sets in non-empty. Therefore, in the corresponding topological graph, adjacency exist between any two vertices and hence we get a complete graph.

Proposition 5.1. The graph G_τ is a null graph if $|X| \leq 2$.

Proof: Let (X, τ) be an ascending topological space and G_τ be the corresponding topological graph. If $|X| = 1$, then $\tau_x = \{\emptyset, X\}$. As we exclude the \emptyset, X in the construction of topological

graph, we have $V(G_\tau) = \emptyset$. If $|X| = 2$, then $\tau_x = \{\emptyset, \{a\}, X\}$. Here $V(G_\tau) = \{a\}$. If $|X| \geq 3$, then $V(G_\tau)$ contains at least two distinct vertices and adjacency exist, as they are in ascending chain in τ . Therefore, the graph G_τ is a null graph if $|X| \leq 2$.

Properties of Ascending Topological Graph

Let (X, τ) be ascending topological space with $|X| \geq 3$ and G_τ be the corresponding topological graph. Since G_τ is a complete graph, G_τ has the following properties

- Number of edges in G_τ is $\frac{p(p-1)}{2}$ where $p = |V(G_\tau)|$.
- G_τ is connected.
- G_τ has no cut vertex.
- G_τ is Hamiltonian.
- G_τ is Eulerian if $|X| = \text{even}$
- G_τ is a Complete Bipartite Graph
- Domination number of G_τ is 1

Theorem 5.2. Let (X, τ) be an ascending topological space with $|X| \geq 3$. Then $\gamma(G_\tau - v) = \gamma(G_\tau) = 1$ and $\gamma(G_\tau - e) = \gamma(G_\tau) = 1$.

Proof: Let (X, τ) be an ascending topological space with $|X| \geq 3$ and G_τ be the corresponding topological graph. Consider the graph $G_\tau - v$. Since G_τ is a complete graph, we again get the complete graph by removing a vertex. As $\gamma(G_\tau) = 1$, we have $\gamma(G_\tau - v) = \gamma(G_\tau)$. Next, we consider the graph $G_\tau - e$. Let the vertices incident with e be v_i, v_j . Then $d(v_i) = d(v_j) = p - 2$. But the remaining all vertices have degree $p - 1$. Therefore, a vertex with degree $p - 1$ covers all the vertices of G_τ . Hence $\gamma(G_\tau - e) = \gamma(G_\tau) = 1$.

Theorem 5.3. [5] Let (X, τ) be an ascending topological space with $|X| \geq 3$. Then $\gamma_{rpd}(G_\tau) = 0$ and $\gamma_{rpd}(G_\tau^v) = 0$.

Theorem 5.4. Let (X, τ) be an ascending topological space with $|X| \geq 3$. Then $\gamma_{rpd}(G_\tau - v) = 0$ and $\gamma_{rpd}(G_\tau - e) = 2$.

Proof: Clearly $\gamma_{rpd}(G_\tau - v) = 0$ as $G_\tau - v$ is a complete graph. Next, consider the graph $G_\tau - e$. Here degree of each vertex is either $p - 1$ or $p - 2$. The vertex of degree $p - 1$ covers all the vertices of $G_\tau - e$. In order to get a relatively prime dominating set, we choose a vertex of degree $p - 2$. Let us say the vertices of degree $p - 1$ and $p - 2$ be u and v respectively. Therefore, relatively prime dominating set = $\{u, v\}$ and thus relatively prime domination number is 2.

Theorem 5.5. Let (X, τ) be an ascending topological space with $|X| \geq 3$. Then $\gamma_{rpd}((G_\tau - v)^v) = 0$.

Proof: Let (X, τ) be an ascending topological space with $|X| \geq 3$ and G_τ be the corresponding topological graph. Consider $G_\tau - v$. Then degree of each vertices is equal, say $p - 2$. Let v be the switching vertex. Then in the graph $(G_\tau - v)^v$, the switching vertex has degree zero and the remaining vertices have degree $p - 3$. Therefore, relatively prime dominating set does not exist. Therefore $\gamma_{rpd}((G_\tau - v)^v) = 0$.

6. Conclusion

In this research article, we explored the relatively prime domination number concerning discrete topological graphs and ascending topological graphs. Furthermore, we delved into the notion of relatively prime domination within switching graphs and modified graphs resulting from edge or vertex deletions or additions. Analogously, we can investigate the graph-theoretical characteristics of topological spaces by transforming them into standard topological graphs.

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2-Dominating Sets and 2- Domination Polynomial of Paths

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ABSTRACT

Let G be a simple connected graph of order n . Let $D_2(G, i)$ be the family of 2-dominating sets in G with cardinality i . The polynomial $D_2(G, x) = \sum_{i=\gamma_2(G)}^n d_2(G, i)x^i$ is called the 2-domination polynomial of G . In this paper we obtain a recursive formula for $d_2(P_n, i)$. Using this recursive formula, I construct the 2-domination polynomial, $D_2(P_n, x) = \sum_{i=\lceil \frac{n+1}{2} \rceil}^n d_2(P_n, i)x^i$, where $d_2(P_n, i)$ is the number of 2-dominating sets of P_n of cardinality i and some properties of this polynomial have been studied.

Keywords: Path, 2-dominating set, 2-domination number, 2-domination polynomial

AMS Subject Classification: 97K30, 05C69, 05C31.

1. Introduction

Let $G = (V, E)$ be a simple graph of order n . For any vertex $v \in V$, the open neighbourhood of V is the set $N(v) = \{u \in V / uv \in E\}$ and the closed neighbourhood of V is the set $N[v] = N(v) \cup \{v\}$ [1]. For a set $S \subseteq V$, the open neighbourhood of S is $N(S) = \bigcup_{v \in S} N(v)$ and the closed neighbourhood of S is $N[S] = N(S) \cup S$. A set $D \subseteq V$ is a dominating set of G if $N[D] = V$ or equivalently, every vertex in $V - D$ is adjacent to at least one vertex in D [4].

The domination number of a graph G is defined as the minimum cardinality taken over all dominating sets D of vertices in G and is denoted by $\gamma(G)$ [2].

I use the notation $\lceil x \rceil$ for the smallest integer greater than or equal to x and $\lfloor x \rfloor$ for the largest integer less than or equal to x . Also, I denote the set $\{1, 2, 3, \dots, n\}$ by $[n]$, throughout this paper.

2. 2 - Dominating Sets of Paths

In this section, I introduce the definition of 2-dominating sets of a graph path and some of its properties.

Definition 2.1. Let G be a simple graph of order n with no isolated vertices. A subset $D \subseteq V$ is a 2-dominating set of the graph G , if every vertex $v \in V - D$ is adjacent to at least 2 vertices

in D . The 2-domination number $\gamma_2(G)$ is the minimum cardinality among the 2-dominating sets of G .

Lemma 2.2. Let P_n be the path with n vertices, then its 2-domination number is $\gamma_2(P_n) = \left\lceil \frac{n+1}{2} \right\rceil$.

Lemma 2.3. Let P_n , $n \geq 4$ be the path with $|V(P_n)| = n$. Then, $d_2(P_n, i) = 0$ if $i < \left\lceil \frac{n+1}{2} \right\rceil$ or $i > n$ and $d_2(P_n, i) > 0$ if $\left\lceil \frac{n+1}{2} \right\rceil \leq i \leq n$.

Proof. If $i < \left\lceil \frac{n+1}{2} \right\rceil$ or $i > n$, then there is no 2-dominating set of cardinality i . Therefore, $D_2(P_n, i) = \emptyset$. By Lemma 2.2, the cardinality of the minimum 2-dominating set is $\left\lceil \frac{n+1}{2} \right\rceil$. Therefore, $d_2(P_n, i) > 0$ if $i \geq \left\lceil \frac{n+1}{2} \right\rceil$ and $i \leq n$. Hence, we have, $d_2(P_n, i) = 0$ if $i < \left\lceil \frac{n+1}{2} \right\rceil$ or $i > n$ and $d_2(P_n, i) > 0$ if $\left\lceil \frac{n+1}{2} \right\rceil \leq i \leq n$.

Lemma 2.4. Let P_n , $n \geq 4$ be the path with $|V(P_n)| = n$.

(i) If $D_2(P_{n-1}, i-1) = \emptyset$ and $D_2(P_{n-3}, i-1) = \emptyset$, then $D_2(P_{n-2}, i-1) = \emptyset$.

(ii) If $D_2(P_{n-1}, i-1) \neq \emptyset$ and $D_2(P_{n-3}, i-1) \neq \emptyset$, then $D_2(P_{n-2}, i-1) \neq \emptyset$.

(iii) If $D_2(P_{n-1}, i-1) = \emptyset$ and $D_2(P_{n-2}, i-1) = \emptyset$, then $D_2(P_n, i) = \emptyset$.

(iv) If $D_2(P_{n-1}, i-1) \neq \emptyset$ and $D_2(P_{n-2}, i-1) \neq \emptyset$ then $D_2(P_n, i) \neq \emptyset$.

Proof. (i) Since $D_2(P_{n-1}, i-1) = \emptyset$ and $D_2(P_{n-3}, i-1) = \emptyset$,

by Lemma 2.3,

$$i-1 > n-1 \text{ or } i-1 < \left\lceil \frac{n}{2} \right\rceil \text{ and } i-1 > n-3 \text{ or } i-1 < \left\lceil \frac{n-2}{2} \right\rceil.$$

$$\text{Therefore, } i-1 > n-1 \text{ or } i-1 < \left\lceil \frac{n-2}{2} \right\rceil.$$

$$\text{Hence, } i-1 > n-2 \text{ or } i-1 < \left\lceil \frac{n-1}{2} \right\rceil \text{ holds. Therefore, } D_2(P_{n-2}, i-1) = \emptyset.$$

(ii) Suppose that $D_2(P_{n-2}, i-1) = \emptyset$, So by Lemma 2.3,

$$\text{we have, } i-1 > n-2 \text{ or } i-1 < \left\lceil \frac{n-1}{2} \right\rceil. \text{ If } i-1 > n-2, \text{ then } i-1 > n-3.$$

$$\text{Therefore, } D_2(P_{n-3}, i-1) = \emptyset, \text{ a contradiction. If } i-1 < \left\lceil \frac{n-1}{2} \right\rceil, \text{ then } i-1 < \left\lceil \frac{n}{2} \right\rceil.$$

$$\text{Therefore, } D_2(P_{n-1}, i-1) = \emptyset, \text{ a contradiction. Hence, } D_2(P_{n-2}, i-1) \neq \emptyset.$$

(iii) Since $D_2(P_{n-1}, i-1) = \emptyset$ and $D_2(P_{n-2}, i-1) = \emptyset$, by Lemma 2.3,

$$i-1 > n-1 \text{ or } i-1 < \left\lceil \frac{n}{2} \right\rceil \text{ and } i-1 > n-2 \text{ or } i-1 < \left\lceil \frac{n-1}{2} \right\rceil.$$

Therefore, $i-1 > n-1$ or $i-1 < \left\lfloor \frac{n-1}{2} \right\rfloor$. Hence, $i > n$ or $i < \left\lfloor \frac{n+1}{2} \right\rfloor$ holds.

Therefore, $D_2(P_n, i) = \phi$.

(iv) By hypothesis, $\left\lfloor \frac{n}{2} \right\rfloor \leq i-1 \leq n-1$ and $\left\lfloor \frac{n-1}{2} \right\rfloor \leq i-1 \leq n-2$.

Therefore, $\left\lfloor \frac{n-1}{2} \right\rfloor \leq i-1 \leq n-1$. Therefore, $\left\lfloor \frac{n+1}{2} \right\rfloor \leq i \leq n$ holds.

Therefore, $D_2(P_n, i) \neq \phi$.

Lemma 2.5. Suppose that $D_2(P_n, i) \neq \phi$, then for every $n \geq 5$, we have

(i) $D_2(P_{n-1}, i-1) = \phi$, $D_2(P_{n-2}, i-1) \neq \phi$, $D_2(P_{n-3}, i-1) \neq \phi$ if and only if $n=2k-1$ and $i = k$ for some $k \geq 3$.

(ii) $D_2(P_{n-2}, i-1) = \phi$, $D_2(P_{n-3}, i-1) = \phi$ and $D_2(P_{n-1}, i-1) \neq \phi$ if and only if $i = n$.

(iii) $D_2(P_{n-1}, i-1) \neq \phi$, $D_2(P_{n-2}, i-1) \neq \phi$ and $D_2(P_{n-3}, i-1) = \phi$ if and only if $i = n-1$.

(iv) $D_2(P_{n-1}, i-1) \neq \phi$, $D_2(P_{n-2}, i-1) \neq \phi$, $D_2(P_{n-3}, i-1) \neq \phi$ iff $\left\lfloor \frac{n}{2} \right\rfloor + 1 \leq i \leq n-2$.

Proof. (i) Assume that $D_2(P_{n-1}, i-1) = \phi$, $D_2(P_{n-2}, i-1) \neq \phi$ and $D_2(P_{n-3}, i-1) \neq \phi$. Since, $D_2(P_{n-1}, i-1) = \phi$, by Lemma 2.3, $i-1 > n-1$ or $i-1 < \left\lfloor \frac{n}{2} \right\rfloor$. If $i-1 > n-1$, then $i > n$, which implies $D_2(P_n, i) = \emptyset$, which is a contradiction. Therefore, $i-1 < \left\lfloor \frac{n}{2} \right\rfloor$. That is, $i \leq \left\lfloor \frac{n}{2} \right\rfloor$ -----(1)

Since, $D_2(P_{n-2}, i-1) \neq \phi$, we have $\left\lfloor \frac{n-1}{2} \right\rfloor \leq i-1 \leq n-2$.

Therefore, $\left\lfloor \frac{n-1}{2} \right\rfloor + 1 \leq i$ -----(2). Since, $D_2(P_{n-3}, i-1) \neq \phi$, we have

$\left\lfloor \frac{n-2}{2} \right\rfloor \leq i-1 \leq n-3$. Therefore, $\left\lfloor \frac{n-2}{2} \right\rfloor + 1 \leq i$ -----(3)

Since, $D_2(P_n, i) \neq \phi$, we have $\left\lfloor \frac{n+1}{2} \right\rfloor \leq i \leq n$, Therefore, $\left\lfloor \frac{n+1}{2} \right\rfloor \leq i$ -----(4)

Combining all these inequalities, we have $\left\lfloor \frac{n+1}{2} \right\rfloor \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor$ -----(5)

when $n \neq 2k-1$, we get an inequality of the form $s \leq i < s$, Which is not possible.

when $n = 2k-1$, (5) holds. In this case $i = k$.

Conversely, assume that $n = 2k-1$ and $i = k$. Therefore, $n-1 = 2k-2$ and $i-1 = k-1$.

Therefore, $k = \frac{n+1}{2}$ and $k-1 = \frac{n-1}{2}$. We have, $i-1 = k-1 = \frac{n-1}{2} < \left\lfloor \frac{n}{2} \right\rfloor$

Therefore, $D_2(P_{n-1}, i-1) = \phi$. Also, $D_2(P_{n-2}, i-1) = D_2(P_{2k-3}, k-1) \neq \phi$, since

$$\left\lceil \frac{2k-3+1}{2} \right\rceil = \left\lceil \frac{2k-2}{2} \right\rceil = k-1. D_2(P_{n-3}, i-1) = D_2(P_{2k-4}, k-1) \neq \phi. \text{ Since}$$

$$\left\lceil \frac{2k-4+1}{2} \right\rceil = \left\lceil \frac{2k-3}{2} \right\rceil = k-1.$$

(ii) Assume that $D_2(P_{n-2}, i-1) = \phi$, $D_2(P_{n-3}, i-1) = \phi$ and $D_2(P_{n-1}, i-1) \neq \phi$.

Since, $D_2(P_{n-2}, i-1) = \phi$ and $D_2(P_{n-3}, i-1) = \phi$, by Lemma 2.3, we have,

$$i-1 > n-2 \text{ or } i-1 < \left\lceil \frac{n-1}{2} \right\rceil \text{ and } i-1 > n-3 \text{ or } i-1 < \left\lceil \frac{n-2}{2} \right\rceil.$$

Therefore, $i-1 > n-2$ or $i-1 < \left\lceil \frac{n-2}{2} \right\rceil$. Since $D_2(P_{n-1}, i-1) \neq \phi$,

we have $\left\lceil \frac{n}{2} \right\rceil \leq i-1 \leq n-1$. If $i-1 < \left\lceil \frac{n-2}{2} \right\rceil$, then $i-1 < \left\lceil \frac{n}{2} \right\rceil$.

Therefore, by Lemma 2.3, $D_2(P_{n-1}, i-1) \neq \phi$, which is a contradiction.

So we have, $i-1 > n-2$. That is, $i > n-1$. Therefore, $i \geq n$ -----(1).

Also, Since $D_2(P_n, i) \neq \phi$, $i \leq n$ -----(2). Combining these we get $i = n$. Conversely, if $i = n$,

$$D_2(P_{n-2}, i-1) = D_2(P_{n-2}, n-1) = \phi$$

$$D_2(P_{n-3}, i-1) = D_2(P_{n-3}, n-1) = \phi$$

$$D_2(P_{n-1}, i-1) = D_2(P_{n-1}, n-1) \neq \phi$$

(iii) Assume that $D_2(P_{n-1}, i-1) \neq \phi$, $D_2(P_{n-2}, i-1) \neq \phi$ and $D_2(P_{n-3}, i-1) = \phi$.

Since, $D_2(P_{n-3}, i-1) = \phi$ then by Lemma 2.3, $i-1 > n-3$ or $i-1 < \left\lceil \frac{n-2}{2} \right\rceil$ -----(1) Since,

$D_2(P_{n-1}, i-1) \neq \phi$, we have $\left\lceil \frac{n}{2} \right\rceil \leq i-1 \leq n-1$ ----- (2)

Suppose, $i-1 < \left\lceil \frac{n-2}{2} \right\rceil$ then (2) does not hold. Therefore our assumption is wrong.

Therefore, $i-1 > n-3$. Also, since $D_2(P_{n-2}, i-1) \neq \phi$, $\left\lceil \frac{n-1}{2} \right\rceil \leq i-1 \leq n-2$ ----- (3)

But, $i-1 > n-3$. Therefore, $i-1 \geq n-2$ ----- (4)

From (3) and (4) we get, $i-1 = n-2$. Therefore, $i = n-1$.

Conversely, Suppose $i = n-1$.

$$\text{Then, } D_2(P_{n-1}, i-1) = D_2(P_{n-1}, n-2) \neq \phi,$$

$$D_2(P_{n-2}, i-1) = D_2(P_{n-2}, n-2) \neq \phi \text{ and } D_2(P_{n-3}, i-1) = D_2(P_{n-3}, n-2) = \phi.$$

(iv) Assume that, $D_2(P_{n-1}, i-1) \neq \phi$, $D_2(P_{n-2}, i-1) \neq \phi$, $D_2(P_{n-3}, i-1) \neq \phi$,

Then by Lemma 2.3, We have, $\left\lceil \frac{n}{2} \right\rceil \leq i-1 \leq n-1$, $\left\lceil \frac{n-1}{2} \right\rceil \leq i-1 \leq n-2$ and

$\left\lceil \frac{n-2}{2} \right\rceil \leq i-1 \leq n-3$. So, $\left\lceil \frac{n}{2} \right\rceil \leq i-1 \leq n-3$ and hence $\left\lceil \frac{n}{2} \right\rceil + 1 \leq i \leq n-2$.

Conversely, Suppose $\left\lceil \frac{n}{2} \right\rceil + 1 \leq i \leq n-2$.

Therefore, $\left\lceil \frac{n}{2} \right\rceil \leq i-1 \leq n-3$. Then,

$\left\lceil \frac{n-1}{2} \right\rceil \leq i-1 \leq n-2$, $\left\lceil \frac{n-2}{2} \right\rceil \leq i-1 \leq n-3$, $\left\lceil \frac{n}{2} \right\rceil \leq i-1 \leq n-1$ holds.

From these we obtain, $D_2(P_{n-2}, i-1) \neq \emptyset$, $D_2(P_{n-3}, i-1) \neq \emptyset$ and $D_2(P_{n-1}, i-1) \neq \emptyset$.

Theorem 2.6. For every $n \geq 3$ and $i > \left\lceil \frac{n+1}{2} \right\rceil$

(i) $D_2(P_{2n-1}, n) = \{1, 3, 5, 7 \dots 2n-1\}$.

(ii) If $D_2(P_{n-2}, i-1) = \emptyset$, $D_2(P_{n-3}, i-1) = \emptyset$ and $D_2(P_{n-1}, i-1) \neq \emptyset$, then $D_2(P_n, i) = D_2(P_n, n) = [n]$.

(iii) If $D_2(P_{n-1}, i-1) \neq \emptyset$, $D_2(P_{n-2}, i-1) \neq \emptyset$ and $D_2(P_{n-3}, i-1) = \emptyset$ then $D_2(P_n, i) = D_2(P_n, n-1) = \{[n] - \{x\} / x \in [n] \text{ and } x \neq 1, n\}$.

(iv) If $D_2(P_{n-1}, i-1) = \emptyset$, $D_2(P_{n-2}, i-1) \neq \emptyset$ then, $D_2(P_n, i) = \{X \cup \{n\} / X \in D_2(P_{n-2}, i-1)\}$.

(v) If $D_2(P_{n-1}, i-1) \neq \emptyset$, $D_2(P_{n-2}, i-1) = \emptyset$ then, $D_2(P_n, i) = \{Y \cup \{n\} / Y \in D_2(P_{n-1}, i-1)\}$.

(vi) $D_2(P_{n-1}, i-1) \neq \emptyset$ and $D_2(P_{n-2}, i-1) \neq \emptyset$ then, $D_2(P_n, i) = \{X \cup \{n\} \cup Y \cup \{n\}\}$ where $X \in D_2(P_{n-2}, i-1)$ and $Y \in D_2(P_{n-1}, i-1)$.

Proof. (i) For every $n \geq 3$, $D_2(P_{2n-1}, n)$ has only one 2-dominating set as, $D_2(P_{2n-1}, n) = \{1, 3, 5, 7, 9 \dots 2n-1\}$.

(ii) Since $D_2(P_{n-2}, i-1) = \emptyset$, $D_2(P_{n-3}, i-1) = \emptyset$ and $D_2(P_{n-1}, i-1) \neq \emptyset$.

By Lemma 2.5, (ii) $i = n$. Therefore, $D_2(P_n, i) = D_2(P_{2n}, n) = [n]$.

(iii) Since, $D_2(P_{n-1}, i-1) \neq \emptyset$, $D_2(P_{n-2}, i-1) \neq \emptyset$ and $D_2(P_{n-3}, i-1) = \emptyset$.

By Lemma 2.5, $i = n-1$.

Therefore, $D_2(P_n, i) = D_2(P_n, n-1) = \{[n] - \{x\} / x \in [n] \text{ and } x \neq 1, n\}$.

(iv) Let X be a 2-dominating set of P_{n-2} with cardinality $i-1$. All the elements of $D_2(P_{n-2}, n-1)$ end with $n-2$. Therefore, $n-2 \in X$, adjoin n with X . Hence, every X of $D_2(P_{n-2}, i-1)$ belongs to $D_2(P_n, i)$ by adjoining n only.

Conversely, Suppose $Z \in D_2(P_n, i)$. Here all the elements of $D_2(P_n, i)$ end with n only. Suppose $n \in Z$, then $Z = X \cup \{n\}$ where X ends with $n-2$.

(v) Let Y be a 2-dominating set of P_{n-1} with cardinality $i-1$. All the elements of $D_2(P_{n-1}, i-1)$ end with $n-1$. Therefore, $n-1 \in Y$, adjoin n with Y . Hence, every Y of $D_2(P_{n-1}, i-1)$ belongs to $D_2(P_n, i)$ by adjoining n only.

$_{1, i-1})$ belongs to $D_2(P_n, i)$ by adjoining n only. Conversely, Suppose $Z \in D_2(P_n, i)$. Here all the elements of $D_2(P_n, i)$ end with n only. Suppose $n \in Z$, then $Z = Y \cup \{n\}$ where Y ends with $n-1$.

(vi) Construction of $D_2(P_n, i)$ from $D_2(P_{n-1}, i-1)$ and $D_2(P_{n-2}, i-1)$.

Let X be a 2-dominating set of P_{n-2} with cardinality $i-1$. All the elements of $D_2(P_{n-2}, i-1)$ end with $n-2$. Therefore, $n-2 \in X$, adjoin n with X . Hence, every X of $D_2(P_{n-2}, i-1)$ belongs to $D_2(P_n, i)$ by adjoining n only. Let Y be a 2-dominating set of P_{n-1} with cardinality $i-1$. All the elements of $D_2(P_{n-1}, i-1)$ end with $n-1$. Therefore, $n-1 \in Y$, adjoin n with Y . Hence, every Y of $D_2(P_{n-1}, i-1)$ belongs to $D_2(P_n, i)$ by adjoining n only. Conversely, Suppose $Z \in D_2(P_n, i)$. Here all the elements of $D_2(P_n, i)$ end with n only. Suppose $n \in Z$, then $Z = \{X \cup \{n\} \cup Y \cup \{n\}\}$ where X ends with $n-2$, $X \in D_2(P_{n-2}, i-1)$ and Y ends with $n-1$, $Y \in D_2(P_{n-1}, i-1)$.

Theorem 2.7. If $D_2(P_n, i)$ be the family of the 2-dominating sets of P_n with cardinality i , where $i \geq \left\lceil \frac{n+1}{2} \right\rceil$ then, $d_2(P_n, i) = d_2(P_{n-1}, i-1) + d_2(P_{n-2}, i-1)$.

Proof. From Theorem 2.6, we consider all the four cases as given below, where $i \geq \left\lceil \frac{n+1}{2} \right\rceil$:

- (i) If $D_2(P_{n-1}, i-1) = \phi$ and $D_2(P_{n-2}, i-1) = \phi$ then $D_2(P_n, i) = \phi$
- (ii) If $D_2(P_{n-1}, i-1) = \phi$, $D_2(P_{n-2}, i-1) \neq \phi$ then, $D_2(P_n, i) = \{X \cup \{n\} / X \in D_2(P_{n-2}, i-1)\}$
- (iii) If $D_2(P_{n-1}, i-1) \neq \phi$, $D_2(P_{n-2}, i-1) = \phi$ then, $D_2(P_n, i) = \{Y \cup \{n\} / Y \in D_2(P_{n-1}, i-1)\}$.
- (iv) $D_2(P_{n-1}, i-1) \neq \phi$ and $D_2(P_{n-2}, i-1) \neq \phi$ then, $D_2(P_n, i) = \{X \cup \{n\} \cup Y \cup \{n\}\}$

where $X \in D_2(P_{n-2}, i-1)$ and $Y \in D_2(P_{n-1}, i-1)$

From the above construction in each case, we obtain that $d_2(P_n, i) = d_2(P_{n-1}, i-1) + d_2(P_{n-2}, i-1)$

3. 2 Domination Polynomials of Paths

Definition 3.1. Let $D_2(P_n, i)$ be the family of the 2-dominating sets of P_n with cardinality i and let $d_2(P_n, i) = |D_2(P_n, i)|$. Then, the 2-domination polynomial $D_2(P_n, x)$ of P_n is defined as, $D_2(P_n, x) = \sum_{i=\gamma_2(P_n)}^n d_2(P_n, i) x^i$, where $\gamma_2(P_n)$ is the 2-domination number of P_n .

Theorem 3.2. For every $n \geq 5$

$D_2(P_n, x) = x [D_2(P_{n-1}, x) + D_2(P_{n-2}, x)]$ with initial values

$$D_2(P_2, x) = x^2$$

$$D_2(P_3, x) = x^2 + x^3$$

Proof. We have $d_2(P_n, i) = d_2(P_{n-1}, i-1) + d_2(P_{n-2}, i-1)$

Therefore, $d_2(P_n, i)x^i = d_2(P_{n-1}, i-1)x^i + d_2(P_{n-2}, i-1)x^i$

$$\sum d_2(P_n, i)x^i = \sum d_2(P_{n-1}, i-1)x^i + \sum d_2(P_{n-2}, i-1)x^i$$

$$\sum d_2(P_n, i)x^i = x \sum d_2(P_{n-1}, i-1)x^{i-1} + x \sum d_2(P_{n-2}, i-1)x^{i-1}$$

$$D_2(P_n, x) = x D_2(P_{n-1}, x) + x D_2(P_{n-2}, x)$$

$$D_2(P_n, x) = x [D_2(P_{n-1}, x) + D_2(P_{n-2}, x)]$$

with the initial values

$$D_2(P_2, x) = x^2$$

$$D_2(P_3, x) = x^2 + x^3$$

We obtain $d_2(P_n, i)$ for $2 \leq n \leq 15$ and $2 \leq i \leq 15$ as shown in Table 1

Table 1

n/i	2	3	4	5	6	7	8	9	10	11	12	13	14	15
P ₂	1													
P ₃	1	1												
P ₄	0	2	1											
P ₅	0	1	3	1										
P ₆	0	0	3	4	1									
P ₇	0	0	1	6	5	1								
P ₈	0	0	0	4	10	6	1							
P ₉	0	0	0	1	10	15	7	1						
P ₁₀	0	0	0	0	5	20	21	8	1					
P ₁₁	0	0	0	0	1	15	35	28	9	1				
P ₁₂	0	0	0	0	0	6	35	56	36	10	1			
P ₁₃	0	0	0	0	0	1	21	70	84	45	11	1		
P ₁₄	0	0	0	0	0	0	7	56	126	120	55	12	1	
P ₁₅	0	0	0	0	0	0	1	28	126	210	165	66	13	1

Theorem 3.3. The following properties hold for the coefficients of $D_2(P_n, x)$.

- (i) $d_2(P_n, n) = 1$, for every $n \geq 2$.
- (ii) $d_2(P_n, n-1) = n-2$, for every $n \geq 3$.
- (iii) $d_2(P_n, n-2) = \frac{1}{2} [n^2 - 7n + 12]$, for every $n \geq 5$.
- (iv) $d_2(P_n, n-3) = \frac{1}{6} [n^3 - 15n^2 + 74n - 120]$, for every $n \geq 7$.
- (v) $d_2(P_n, n-4) = \frac{1}{24} [n^4 - 26n^3 + 251n^2 - 1066n + 1680]$, for every $n \geq 8$.
- (vi) $d_2(P_{2n+1}, n+1) = 1$, for every $n \geq 1$.
- (vii) $d_2(P_{2n}, n+1) = n$, for every $n \geq 2$.

4. Conclusion

In this paper, 2-domination polynomials of paths has been derived by identifying its 2-dominating sets. It also help us to characterize the 2-dominating sets of cardinality i . We can generalize this study to any power of path and some interesting properties can be obtained via the roots of the 2-domination polynomial of P_n .

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Modified Wiener Index and Modified Hyper Wiener Index of a Nanorod Graph

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ABSTRACT

Numeric features called molecular topological descriptors are crucial for predicting the bioactivity of molecular structures effectively. In this article, we calculate the distance based topological indices, including the modified Wiener index and modified hyper-Wiener index for a Nanorod graph.

Keywords: Modified hyper- Wiener index, Modified Wiener index, Nanorod graph.

AMS Subject Classification: 05C90, 05C92

1. Introduction

For notations and terminology related to graph theory not included here, we refer to [1]. In mathematical chemistry, the graphical representation of a chemical compound is an illustration of its structural formula [2]. Chemical graph theory is a branch of theoretical chemistry that employs graph theory to represent and analyze the structural aspects of molecules. In this framework, atoms are depicted as vertices, and chemical bonds are represented as edges connecting these vertices. The application of graph theory to chemical structures allows for the exploration of molecular connectivity topological indices. A topological index is a numerical constant associated with a molecular descriptor. It is also recognized as a graph-theoretic index, representing a numerical measure tied to the structure of the molecular graph and reflective of distinct chemical and physical properties. Topological indices fall into various classes, encompassing distance-based, degree-based, and eccentricity-based indices [3].

The Wiener index, introduced by Harry Wiener in 1947, is the sum of distances between all pairs of vertices in a graph. Harry Wiener demonstrated the correlation between the Wiener index and various properties of alkanes in a series of research articles published from 1947 to 1948 [4, 5]. The Wiener index garnered significant interest among mathematicians around 1970 when it was introduced in graph theory as the “distance of a graph.” It was subsequently explored further in the context of the average distance of a graph [6, 7, 8].

In this article, we analyze distance-based topological indices for the optical properties of a Nanorod graph. The authors, Sonia et al. [9], conducted prior research examining the bioactivity of CuO nanorods synthesized under different concentrations of NaOH. The Nanorod graph was defined and generated by S. Sobiya, S. Sujitha, and M. K. Angel Jebitha using the methodology outlined in [10]. The distance between any pair of vertices is denoted by $d(u, v)$ and is the length of the shortest path between the two vertices.

Definition 1.1.[11] For a simple connected graph G , the modified Wiener index is denoted by $W_\lambda(G)$ and is defined as $W_\lambda(G) = \frac{1}{2} \sum_{u,v \in V(G)} d(u, v)^\lambda$ where λ is any positive integer.

Definition 1.2.[11] For a simple connected graph G , the modified hyper-Wiener index denoted by $WW_\lambda(G)$, and is defined as $WW_\lambda(G) = \frac{1}{2} \sum_{u,v \in V(G)} [d(u, v)^\lambda + d(u, v)^{2\lambda}]$ where λ is any positive integer.

2. Nanorod graph

The Nanorod graph is a simple, connected graph, and is denoted by G_{Nr} . In a Nanorod graph, the vertex set $V(G_{Nr})$ corresponds to different NaOH concentrations and an edge set $E(G_{Nr})$ corresponds to the UV spectrum parameters. In this article, we leverage ten step values, designated as 'k' [i.e. $k = 0.1, 0.09, 0.08, 0.07, 0.06, 0.05, 0.04, 0.03, 0.02, 0.01$]. The order of the Nanorod graph, represented as ' p ' ($p = \left\lfloor \frac{1.5}{k} + 1 \right\rfloor$) and the size is ' q ' and the reaction time is $t = 2$ and $pH = 12$ in the comprehensive study of topological indices.

Figure 1 shows a Nanorod graph with step value $k = 0.1$

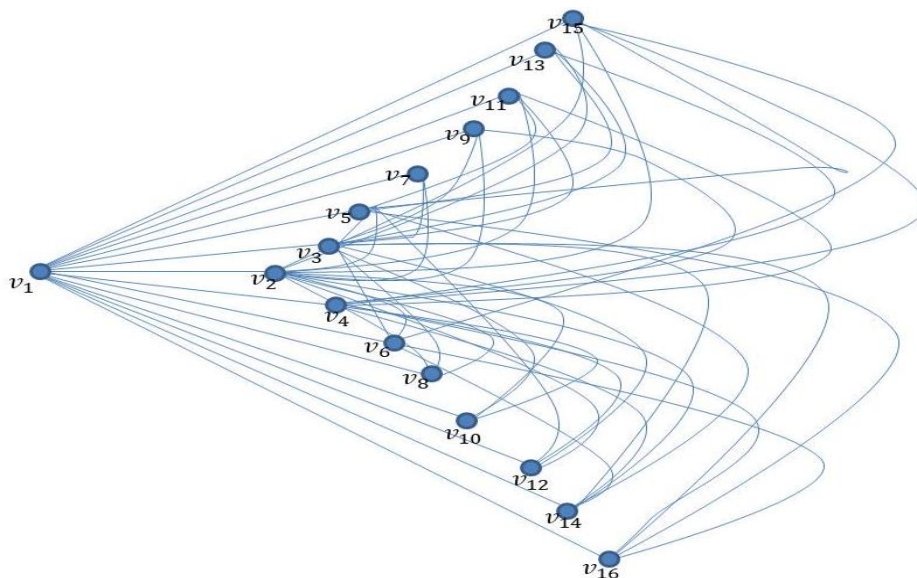


Figure 1: Nanorod graph G_{Nr} with $k = 0.1$

3. The Distance Based Topological Indices of a Nanorod Graph

In this section, we establish formulae for distance-based topological indices, including the modified Wiener index and modified hyper-Wiener index, for a Nanorod graph. Here, λ represents any positive integer, and we consider λ as the NaOH concentration (i.e., 0.5, 1, 1.5, 2).

Theorem 3.1 For a Nanorod graph G_{Nr} , the modified Wiener index is $W_\lambda(G_{Nr}) =$

$$\begin{cases} \left[\frac{2^\lambda}{2} \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^\lambda \right] + \frac{1}{2} [size(q)]^\lambda \text{ if } k = 0.1, n = t - 1, k = 0.09, n = t, k = 0.08, \\ n = t + 1 \text{ and } k = 0.07, k = t + 2 \\ \left[\frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^\lambda \right] + \frac{1}{2} [size(q)]^\lambda \text{ if } k = 0.06, n = t - 1, k = 0.05, n = t \text{ and } \\ k = 0.04, n = t + 1 \\ \left[\frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^\lambda \right] + \frac{1}{2} [size(q)]^\lambda \text{ if } k = 0.03, n = t - 1, k = 0.02, n = t \text{ and } \\ k = 0.01, n = t + 1 \end{cases}$$

Proof. We know that the modified Wiener index of a Nanorod graph G_{Nr} is

$$W_\lambda(G_{Nr}) = \frac{1}{2} \sum_{u,v \in V(G_{Nr})} d(u,v)^\lambda$$

It's clear that, the distance between any of any vertices of a Nanorod graph is either one or two.

Case(i) : $d(u,v) = 1$ for all $u,v \in V(G_{Nr})$ and for all k

In this case, $W_\lambda(G_{Nr}) = \frac{1}{2} \sum_{u,v \in V(G_{Nr})} d(u,v)^\lambda$

$$= \frac{1}{2} [d(u_1, v_1) + \dots + d(u_2, v_2) + \dots \dots + d(u_n, v_n) + \dots \dots]^\lambda$$

$$= \frac{1}{2} [1 + 1 + \dots \dots]^\lambda$$

$$= \frac{1}{2} [size(q)]^\lambda$$

Case(ii) : $d(u,v) = 2$ for all $u,v \in V(G_{Nr})$ and for different k

Subcase (a) : $k = 0.1, 0.09, 0.08$ and 0.07

$$W_\lambda(G_{Nr}) = \frac{1}{2} [d(u_1, v_2) + \dots + d(u_2, v_3) + \dots \dots \dots]^\lambda$$

$$\begin{aligned}
&= \frac{1}{2} [2 + 2 + 2 + \cdots \dots]^\lambda \\
&= \frac{1}{2} \left[\left[3p + \frac{p}{pH} (n^3 - 6n^2 + 15n - 8) + \frac{p}{1.5} \right] 2 \right]^\lambda \\
&= \frac{2^\lambda}{2} \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^\lambda
\end{aligned}$$

Subcase (b) : $k = 0.06, 0.05$ and 0.04

$$\begin{aligned}
W_\lambda(G_{Nr}) &= \frac{1}{2} [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^\lambda \\
&= \frac{1}{2} [2 + 2 + 2 + \cdots \dots]^\lambda \\
&= \frac{1}{2} \left[\left[3p + \left[\frac{p}{pH} \left[\frac{p}{0.5} - (2n^2 - 15n + 31) \right] + \frac{p}{1.5} \right] 2 \right] \right]^\lambda \\
&= \frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^\lambda
\end{aligned}$$

Subcase (c) : $k = 0.03, 0.02$ and 0.01

$$\begin{aligned}
W_\lambda(G_{Nr}) &= \frac{1}{2} [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^\lambda \\
&= \frac{1}{2} [2 + 2 + 2 + \cdots \dots]^\lambda \\
&= \frac{1}{2} \left[\left[3p + \left[\frac{p}{pH} \left[\frac{p}{0.5} + (36.7n^2 - 77.5n + 57.2) \right] + \frac{p}{1.5} \right] 2 \right] \right]^\lambda \\
&= \frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^\lambda
\end{aligned}$$

From Case(i) and Case(ii), we have

$W_\lambda(G_{Nr})$ for the Nanorod graph with step value $k = 0.1, 0.09, 0.08$ and 0.07

$$W_\lambda(G_{Nr}) = \frac{2^\lambda}{2} \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^\lambda + \frac{1}{2} [size(q)]^\lambda$$

$W_\lambda(G_{Nr})$ for the Nanorod graph with step value $k = 0.06, 0.05$ and 0.04

$$W_{\lambda}(G_{Nr}) = \frac{2^{\lambda}}{2} \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^{\lambda} + \frac{1}{2} [size(q)]^{\lambda}$$

$W_{\lambda}(G_{Nr})$ for the Nanorod graph with step value $k = 0.03, 0.02$ and 0.01

$$W_{\lambda}(G_{Nr}) = \frac{2^{\lambda}}{2} \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^{\lambda} + \frac{1}{2} [size(q)]^{\lambda}$$

Theorem 3.2 Let G_{Nr} be a Nanorod graph. Then the modified hyper- Wiener index is

$$WW_{\lambda}(G_{Nr}) = \begin{cases} \frac{2^{\lambda}}{2} \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^{\lambda} [1 + \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^{\lambda} 2^{\lambda}] + \frac{[size(q)]^{\lambda}(1 + size(q))^{\lambda}}{2} \\ \text{if } k = 0.1, n = t - 1, k = 0.09, n = t, k = 0.08, n = t + 1 \text{ and } k = 0.07, n = t + 2 \\ \frac{2^{\lambda}}{2} \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^{\lambda} [1 + \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^{\lambda} 2^{\lambda}] + \frac{[size(q)]^{\lambda}(1 + size(q))^{\lambda}}{2} \\ \text{if } k = 0.06, n = t - 1, k = 0.05, n = t \text{ and } k = 0.04, n = t + 1 \\ \frac{2^{\lambda}}{2} \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^{\lambda} [1 + \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^{\lambda} 2^{\lambda}] \\ + \frac{[size(q)]^{\lambda}(1 + size(q))^{\lambda}}{2} \text{if } k = 0.03, n = t - 1, k = 0.02, n = t \text{ and } k = 0.01, n = t + 1 \end{cases}$$

Proof. We know that the modified hyper- Wiener index is

$$WW_{\lambda}(G_{Nr}) = \frac{1}{2} \sum_{u,v \in E(G_{Nr})} [d(u, v)^{\lambda} + (d(u, v))^{2\lambda}]$$

Since the distance between any pair of vertices of a Nanorod graph is either one or two, we have two cases.

Case(i) : $d(u, v) = 1$ for all $u, v \in V(G_{Nr})$ and for all k

$$\begin{aligned} \text{In this case, } WW_{\lambda}(G_{Nr}) &= \frac{1}{2} \sum_{uv \in V(G_{Nr})} [d(u, v)^{\lambda} + (d(u, v))^{2\lambda}] \\ &= \frac{1}{2} [[d(u_1, v_1) + \dots + d(u_2, v_2) + \dots + d(u_n, v_n) + \dots]^{\lambda} \\ &\quad + [d(u_1, v_1) + \dots + d(u_2, v_2) + \dots + d(u_n, v_n) + \dots]^{2\lambda}] \\ &= \frac{1}{2} [[1 + 1 + \dots]^{\lambda} + [1 + 1 + \dots]^{2\lambda}] \\ &= \frac{[size(q)]^{\lambda}(1 + size(q))^{\lambda}}{2} \end{aligned}$$

Case(ii): $d(u, v) = 2$ for all $u, v \in V(G_{Nr})$ and for different k

Subcase (a): $k = 0.1, 0.09, 0.08, 0.07$

$$\begin{aligned}
 WW_\lambda(G_{Nr}) &= \frac{1}{2} \{ [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^\lambda \\
 &\quad + [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^{2\lambda} \} \\
 &= \frac{1}{2} \left\{ \left[3p + \left(\frac{p}{pH} (n^3 - 6n^2 + 15n - 8) + \frac{p}{1.5} \right) \right] 2^\lambda \right. \\
 &\quad \left. + \left[3p + \left(\frac{p}{pH} (n^3 - 6n^2 - 15n - 8) + \frac{p}{1.5} \right) \right]^{2\lambda} 2^{2\lambda} \right\} \\
 &= \frac{2^\lambda}{2} \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^\lambda [1 \\
 &\quad + \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^\lambda 2^\lambda]
 \end{aligned}$$

Subcase (b): $k = 0.06, 0.05, 0.04$

$$\begin{aligned}
 WW_\lambda(G_{Nr}) &= \frac{1}{2} \{ [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^\lambda \\
 &\quad + [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^{2\lambda} \} \\
 &= \frac{1}{2} \left\{ \left[3p + \left(\frac{p}{pH} \left(\frac{p}{0.5} - (2n^2 - 15n + 31) \right) + \frac{p}{1.5} \right) \right]^\lambda 2^\lambda \right. \\
 &\quad \left. + \left[3p + \left(\frac{p}{pH} \left(\frac{p}{0.5} - (2n^2 - 15n + 31) \right) + \frac{p}{1.5} \right) \right]^{2\lambda} 2^{2\lambda} \right\} \\
 &= \frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^\lambda [1 \\
 &\quad + \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^\lambda 2^\lambda]
 \end{aligned}$$

Subcase (c): $k = 0.03, 0.02$ and 0.01

$$\begin{aligned}
 WW_\lambda(G_{Nr}) &= \frac{1}{2} \{ [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^\lambda \\
 &\quad + [d(u_1, v_2) + \cdots + d(u_2, v_3) + \cdots \dots \dots]^{2\lambda} \}
 \end{aligned}$$

$$\begin{aligned}
&= \frac{1}{2} \left\{ \left[3p + \left(\frac{p}{pH} \left(\frac{p}{0.5} + (36.7n^2 - 77.5n + 57.2) \right) + \frac{p}{1.5} \right) \right]^\lambda 2^\lambda + \left[3p \right. \right. \\
&\quad \left. \left. + \left(\frac{p}{pH} \left(\frac{p}{0.5} + (36.7n^2 - 77.5n + 57.2) \right) + \frac{p}{1.5} \right) \right]^{2\lambda} 2^{2\lambda} \right\} \\
&= \frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^\lambda [1 \\
&\quad + \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^\lambda 2^\lambda]
\end{aligned}$$

Therefore, from Case (i) and Case(ii) we have

$W_\lambda(G_{Nr})$ for the Nanorod graph with step value $k = 0.1, 0.09, 0.08$ and 0.07

$$\begin{aligned}
WW_\lambda(G_{Nr}) &= \frac{2^\lambda}{2} \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^\lambda [1 \\
&\quad + \left[\frac{4.5p}{1.5} + \frac{p}{pH} n^3 - \frac{6p}{pH} n^2 + \frac{15p}{pH} n - \frac{8p}{pH} \right]^\lambda 2^\lambda] \\
&\quad + \frac{[size(q)]^\lambda (1 + size(q))^\lambda}{2}
\end{aligned}$$

$W_\lambda(G_{Nr})$ for the Nanorod graph with step value $k = 0.06, 0.05$ and 0.04

$$\begin{aligned}
WW_\lambda(G_{Nr}) &= \frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^\lambda [1 \\
&\quad + \left[\frac{p^2}{0.5pH} - \frac{2p}{pH} n^2 + \frac{15p}{pH} n - \frac{31p}{pH} + \frac{4.5p}{1.5} \right]^\lambda 2^\lambda] \\
&\quad + \frac{[size(q)]^\lambda (1 + size(q))^\lambda}{2}
\end{aligned}$$

$W_\lambda(G_{Nr})$ for the Nanorod graph with step value $k = 0.03, 0.02$ and 0.01

$$\begin{aligned}
WW_\lambda(G_{Nr}) &= \frac{2^\lambda}{2} \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^\lambda [1 \\
&\quad + \left[\frac{p^2}{0.5pH} + \frac{36.7p}{pH} n^2 - \frac{77.5p}{pH} n + \frac{57.2p}{pH} + \frac{4.5p}{1.5} \right]^\lambda 2^\lambda] \\
&\quad + \frac{[size(q)]^\lambda (1 + size(q))^\lambda}{2}
\end{aligned}$$

4. Conclusion

In this article, we calculated the distance based topological indices such as modified Wiener index and modified hyper-Wiener index of a Nanorod graph G_{Nr} with respective order p , time t and pH value.

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A Study on Srivastava and Singh's Refined Arithmetic Model of Fuzzy Time Series Forecasting

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ABSTRACT

In recent decades, a number of forecasting models based on the ideas of fuzzy time series have been put forth. These models have been widely used to address a wide range of problem domains, particularly those involving forecasting when the historical data are linguistic values. The development of fuzzy time series, the creation of a time-invariant model, and its application to coal production forecasts are presented in this study. It includes an analysis of the revised arithmetic model developed by Srivastava and Singh, along with estimates conducted to predict India's coal production. The 40 years of historical data serve as the foundation for the time series forecasting. Error estimates are used to analyse this model. The suggested approach is used to forecast data on coal production.

Keywords: Arithmetic model, Coal production, Fuzzy time series, Srivastava and Singh.

1.Introduction

A time series is a sequence of discrete temporal data that is uniformly spaced. It may include some or all of the following components: trend, cyclical, seasonal, and irregular. A trend is a long-term pattern, whereas a cyclical is a sequence of up and down movements.

Seasonal, on the other hand, is a consistent change within the same month or quarter, whereas irregular is an unexplained random component. Forecasting is the prediction of future values based on previous and current time series data trends. Short-term forecasting (STF), medium-term forecasting (MTF), and long-term forecasting (LTF) are the three types of forecasting.

Zadeh firstly proposed the concept of fuzzy set theory in 1965. Song and Chissom [1], based on Zadeh's work, were the first to apply the concept of the fuzzy set to time series and build a first-order time-invariant Fuzzy time series model in 1993. Song and Chissom later applied time-invariant and time-variant FTS on Alabama University enrollment from 1971 to 1992. Chen [2] proposed other method of defuzzification on arithmetic operations. Ravi [3] analysis based on opinion mining for CRM in financial services.

2. Basic Definitions

Definition 1:

Let $U = \{u_1, u_2, \dots, u_n\}$ be a universe of discourse (universal set); a fuzzy set A of U is defined $A = f_A(u_1)/u_1 f_A(u_2)/u_2 \dots f_A(u_n)/u_n$, where f_A is a membership function of a given set A , $f_A : U \rightarrow [0,1]$.

Definition 2 [1]:

Let $Y(t)$, $(t = \dots, 0, 1, 2, \dots)$, a subset of U , be the universe of discourse defined by the fuzzy set $\mu_i(t)$. If $F(t)$ consists of $\mu_i(t)$ ($i=1,2,3,\dots$), $F(t)$ is called a fuzzy time series on $Y(t)$.

Definition 3:

If there exist a fuzzy relationship $R(t-1, t)$, such that $F(t) = F(t-1) \circ R(t-1, t)$ where \circ is an arithmetic operator, then $F(t)$ is said to be caused by $F(t-1)$. The relationship between $F(t)$ and $F(t-1)$ can be denoted by $F(t-1) \rightarrow F(t)$.

Definition 4:

Suppose $F(t)$ is calculated by $F(t-1)$ only, and $F(t) = F(t-1) \circ R(t-1, t)$. For any t , if $R(t-1, t)$ is independent of t , then $F(t)$ is considered a time invariant fuzzy time series. Otherwise, $F(t)$ is time – variant.

Definition 5:

Suppose $F(t-1) = A_i$ and $F(t) = A_j$, a fuzzy logical relationship can be defined as $A_i \rightarrow A_j$ Where A_i and A_j are called the left-hand side and the right-hand side of the fuzzy

Definition 6: A membership function for a fuzzy set A on the universe of discourse X is defined as $\mu_A : X \rightarrow [0,1]$, where each element of X is mapped to a value between 0 and 1. This value, called membership value or degree of membership, quantifies the grade of membership of the element in X to the fuzzy set A .

3. First Order Fuzzy Relations in time invariant model

Suppose $F(t)$ as a fuzzy time series $(t = 0, 1, 2, \dots)$. For the first order model $R(t, t-1)$ of $F(t)$ for any $f_1(t) \in F(t)$ where $j \in J$ there exist an $f_1(t-1) \in F(t-1)$ where $I \in I$ then the fuzzy relation $R_{ij}(t, t-1)$ is such that

$$f_j(t) = f_i(t-1) \circ R_{ij}(t, t-1)$$

which is equivalent to IF.....THEN rule as “IF $f_i(t-1)$ THEN $f_j(t)$ ”

$$R_i(t, t-1) = \bigcup_{ij} R_{ij}(t, t-1)$$

$$R_{ij}(t, t-1) = f_i(t-1) \times f_j(t)$$

Here the operator “ \circ ” is called Mamdani type max min operator.

4. Fuzzy Time Series Production Forecasting: Algorithm

The following stages can be used to create and implement a fuzzy time series forecasting model:

Step 1: Define the universe of discourse using the time series data on which fuzzy sets are to be formed.

Step 2: Divide the universe of discourse into equal length periods [4].

Step 3: Define the fuzzy sets (linguistic variables) on the universe of discourse.

Step 4: Fuzzification of time series coal production data for fuzzy input.

Step 5: Calculate the fuzzy logical relationships [5].

Step 6: Calculate the predicted coal production (fuzzy output).

Step 7: Defuzzification of the fuzzy output of coal production for Crisp forecasting.

5. Computational Techniques: The implementation of the aforesaid algorithm for coal production projection is based on a 40-year period (1980-2019).

Step 1: Define the discourse universe in relation to the time series data. It requires the minimum and maximum output to be configured as D_{min} and D_{max} . Thus, U is defined as $[D_{min} - D_1, + D_{max} + D_2]$, where D_1 and D_2 are two valid positive numbers. In the current situation of production forecasting, the computed universe of discourse is $U = [100-800]$.

Step 2: Divide the universes of discourse into 7 equal length intervals u_1, u_2, \dots, u_7 , such that $u_1 = [100 - 200], u_2 = [200 - 300], u_3 = [300 - 400], u_4 = [400 - 500], u_5 = [500 - 600], u_6 = [600 - 700], u_7 = [700 - 800]$.

Step 3: Define 7 fuzzy sets A_1, A_2, \dots, A_7 having linguistic values on the universe of discourse U . The following are the linguistic values to these fuzzy variables:

A_1 : low production, A_2 : under average production, A_3 : usual production,
 A_4 : good production, A_5 : fantastic production, A_6 : excellent production,
 A_7 : extra ordinarily huge production.

The membership of these fuzzy sets to distinct intervals is as follows:

$$A_1 : [1/u_1, .5/u_2, 0/u_3, 0/u_4, 0/u_5, 0/u_6, 0/u_7]$$

$$A_2 : [.5/u_1, 1/u_2, 0.5/u_3, 0/u_4, 0/u_5, 0/u_6, 0/u_7]$$

$$A_3 : [0/u_1, .5/u_2, 1/u_3, 0.5/u_4, 0/u_5, 0/u_6, 0/u_7]$$

$$A_4 : [0/u_1, 0/u_2, 0.5/u_3, 1/u_4, 0.5/u_5, 0/u_6, 0/u_7]$$

$$A_5 : [0/u_1, 0/u_2, 0/u_3, 0.5/u_4, 1/u_5, 0.5/u_6, 0/u_7]$$

$$A_6 : [0/u_1, 70/u_2, 0/u_3, 0/u_4, 0.5/u_5, 1/u_6, 0.5/u_7]$$

$$A_7 : [0/u_1, 0/u_2, 0/u_3, 0/u_4, 0/u_5, 0.5/u_6, 1/u_7]$$

Step4: Fuzzification of time series data of coal production for the fuzzy input [6] to the models are as follow.

Table 1: Fuzzification of time series data of coal production

Year	Production Data	A_1	A_2	A_3	A_4	A_5	A_6	A_7	Fuzzified Production
1980	13.9	1	0.5	0	0	0	0	0	A_1
1981	124.2	1	0.5	0	0	0	0	0	A_1
1982	130.5	1	0.5	0	0	0	0	0	A_1
1983	138.2	1	0.5	0	0	0	0	0	A_1
1984	147.4	1	0.5	0	0	0	0	0	A_1
1985	154.2	1	0.5	0	0	0	0	0	A_1
1986	165.8	1	0.5	0	0	0	0	0	A_1
1987	179.7	1	0.5	0	0	0	0	0	A_1
1988	194.6	1	0.5	0	0	0	0	0	A_1
1989	200.9	0.5	1	0.5	0	0	0	0	A_2
1990	211.1	0.5	1	0.5	0	0	0	0	A_2
1991	229.3	0.5	1	0.5	0	0	0	0	A_2
1992	238.3	0.5	1	0.5	0	0	0	0	A_2
1993	246.0	0.5	1	0.5	0	0	0	0	A_2
1994	253.8	0.5	1	0.5	0	0	0	0	A_2
1995	270.1	0.5	1	0.5	0	0	0	0	A_2
1996	285.7	0.5	1	0.5	0	0	0	0	A_2
1997	295.9	0.5	1	0.5	0	0	0	0	A_2
1998	292.3	0.5	1	0.5	0	0	0	0	A_2
1999	300.0	0.5	1	0.5	0.5	0	0	0	A_2
2000	309.6	0	0.5	1	0.5	0	0	0	A_3
2001	327.8	0	0.5	1	0.5	0	0	0	A_3
2002	341.3	0	0.5	1	0.5	0	0	0	A_3
2003	361.3	0	0.5	1	0.5	0	0	0	A_3
2004	382.6	0	0.5	1	0.5	0	0	0	A_3
2005	407.0	0	0	0.5	1	0.5	0	0	A_4
2006	430.8	0	0	0.5	1	0.5	0	0	A_4
2007	457.1	0	0	0.5	1	0.5	0	0	A_4

2008	492.8	0	0	0.5	1	0.5	0	0	A_4
2009	532.0	0	0	0	0.5	1	0.5	0	A_5
2010	532.7	0	0	0	0.5	1	0.5	0	A_5
2011	540.0	0	0	0	0.5	1	0.5	0	A_5
2012	556.4	0	0	0	0.5	1	0.5	0	A_5
2013	565.8		0	0	0.5	1	0.5	0	A_5
2014	609.2		0	0	0	0.5	1	0.5	A_6
2015	639.2		0	0	0	0.5	1	0.5	A_6
2016	657.8		0	0	0	0.5	1	0.5	A_6
2017	675.4		0		0	0.5	1	0.5	A_6
2018	728.7		0		0	0	0.5	1	A_7
2019	730.8		0		0	0	0.5	1	A_7

Step 5: The fuzzy logical relationships have obtained from the table 1 are as:

Table 2: Fuzzy logical relationships of the historical coal production

$A_1 \rightarrow A_1, A_1 \rightarrow A_1, A_1 \rightarrow A_1, A_1 \rightarrow A_1, A_1 \rightarrow A_1, A_1$ $\rightarrow A_1, A_1 \rightarrow A_1, A_1 \rightarrow A_1, A_1 \rightarrow A_2$ $A_2 \rightarrow A_2, A_2 \rightarrow A_2, A_2 \rightarrow A_2, A_2 \rightarrow A_2, A_2 \rightarrow A_2, A_2 \rightarrow A_2,$ $A_2 \rightarrow A_2, A_2 \rightarrow A_2, A_2 \rightarrow A_2, A_2 \rightarrow A_2, A_2 \rightarrow A_3$ $A_3 \rightarrow A_3, A_3 \rightarrow A_3, A_3 \rightarrow A_3, A_3 \rightarrow A_3, A_3 \rightarrow A_4$ $A_4 \rightarrow A_4, A_4 \rightarrow A_4, A_4 \rightarrow A_4, A_4 \rightarrow A_5$ $A_5 \rightarrow A_5, A_5 \rightarrow A_5, A_5 \rightarrow A_5, A_5 \rightarrow A_5, A_5 \rightarrow A_6$ $A_6 \rightarrow A_6, A_6 \rightarrow A_6, A_6 \rightarrow A_6, A_6 \rightarrow A_7$ $A_7 \rightarrow A_7$

Table 3: Fuzzy logical relationship groups

1	$A_1 \rightarrow A_1$	$A_1 \rightarrow A_2$
2	$A_2 \rightarrow A_2$	$A_2 \rightarrow A_3$
3	$A_3 \rightarrow A_3$	$A_3 \rightarrow A_4$
4	$A_4 \rightarrow A_4$	$A_4 \rightarrow A_5$
5	$A_5 \rightarrow A_5$	$A_5 \rightarrow A_6$
6	$A_6 \rightarrow A_6$	$A_6 \rightarrow A_7$
7	$A_7 \rightarrow A_7$	

The fuzzy time invariant relation R from above 13 logical relations can be obtained as:

$R = \cup R_i$ here \cup is the Union operator. Whereas the calculations of R_i ($i = 1, 2, \dots, 13$) are carried out by "IF.... THEN" with the process: If sets A and B are row vectors of order p and the logical relation between them is such that $A \rightarrow B$, then fuzzy relation R_1 is obtained in form of a matrix $C = A^T \times B$ of dimension $p \times p$, here $C_{ij} = \min(A_i, B_j)$ ($i, j = 1 - p$). Thus computation all the fuzzy logical relations R_1, \dots, R_{13} and taking the union of these computed relations, we obtain a fuzzy time invariant relation R as

$$R = \begin{bmatrix} 1 & 1 & 0.5 & 0 & 0 & 0 & 0 \\ 0.5 & 1 & 1 & 0.5 & 0 & 0 & 0 \\ 0 & 0.5 & 1 & 1 & 0.5 & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 & 1 \end{bmatrix}$$

Step 6: Computation of fuzzy forecast of the coal production have been carried by the model

6. Srivastava and Singh's Refined Arithmetic Model [6]

1. If the fuzzified production of the year is A_j , and there is only one fuzzy logical relationship in the fuzzy logical relationship groups in Table 3 in which the recent state of the production is A_j , then the fuzzy forecasted production of the year is $i + 1$ is A_j .

2. If the fuzzified production of the year is A_j and there are fuzzy logical relationships in the fuzzy logical relationship group as:

$A_j \rightarrow A_{k1}, A_j \rightarrow A_{k2}, \dots, A_j \rightarrow A_{kn}$, the A_j forming a relation with $A_{k1}, A_{k2}, \dots, A_{kn}$ is the fuzzy forecasted production of the year $i + 1$

3. It also counts the repetitive relations and the frequency is recorded and is used for defuzzification (crisp output).

Step 7: Defuzzification [6] is the development by which fuzzy output of model is converted to crisp values for getting the predicted values. The output of model is defuzzified in the following [7]:

1. If the production of the year i is A_j and fuzzy logical relation is $A_j \rightarrow A_k$ and A_k has max membership in interval u_k , then the estimated production for the year $i = 1$ will be midpoint of A_k .

2. If the fuzzified production of the year i is A_j and there are fuzzy logical relationships in the fuzzy logical relationship group as:

$A_j \rightarrow A_{k1}, A_j \rightarrow A_{k2}, \dots, A_j \rightarrow A_k, A_{k1}, A_{k2}, \dots, A_{kn}$ has max membership in the intervals $u_{k1}, u_{k2}, \dots, u_{kn}$ Respectively and m_1, m_2, \dots, m_n are their respective midpoints, then the forecasted production for the year $i + 1$ will be $(m_1 + m_2 + \dots + m_n)/n$.

3. If the fuzzified production of the year is A_j , and no logical relationship is found in logical relationship groups, whose current state of production is A_j , where the maximum membership value of A_j occurs at interval u_j and the midpoint u_j of m_j is then the forecasted production of year $i + 1$ is m_j .

4. Repeated relations and according weighted mean is computed keeping in view of their frequencies.

7. Results and Discussion

Table 4: Forecasting Result of Coal Production Data

Year	Actual Production	Forecasted method	Year	Actual Production	Forecasted method
1980	113.9	161.1	2001	327.8	370
1981	124.2	161.1	2002	341.3	370
1982	130.5	161.1	2003	361.3	370
1983	138.2	161.1	2004	382.6	370
1984	147.4	161.1	2005	407.0	475
1985	154.2	161.1	2006	430.8	475
1986	165.8	161.1	2007	457.1	475
1987	179.7	161.1	2008	492.8	475
1988	194.6	161.1	2009	532.0	570
1989	211.1	259.09	2010	532.7	570
1991	229.3	259.09	2011	540.0	570
1992	238.3	259.09	2012	556.4	570
1993	246.0	259.09	2013	565.8	570
1994	253.8	259.09	2014	609.2	675
1995	270.1	259.09	2015	639.2	675

1996	285.7	259.09	2016	657.8	675
1997	295.9	259.09	2017	675.4	675
1998	292.3	259.09	2018	728.7	750
1999	300.0	259.09	2019	730.8	750
2000	309.6	370	2020		

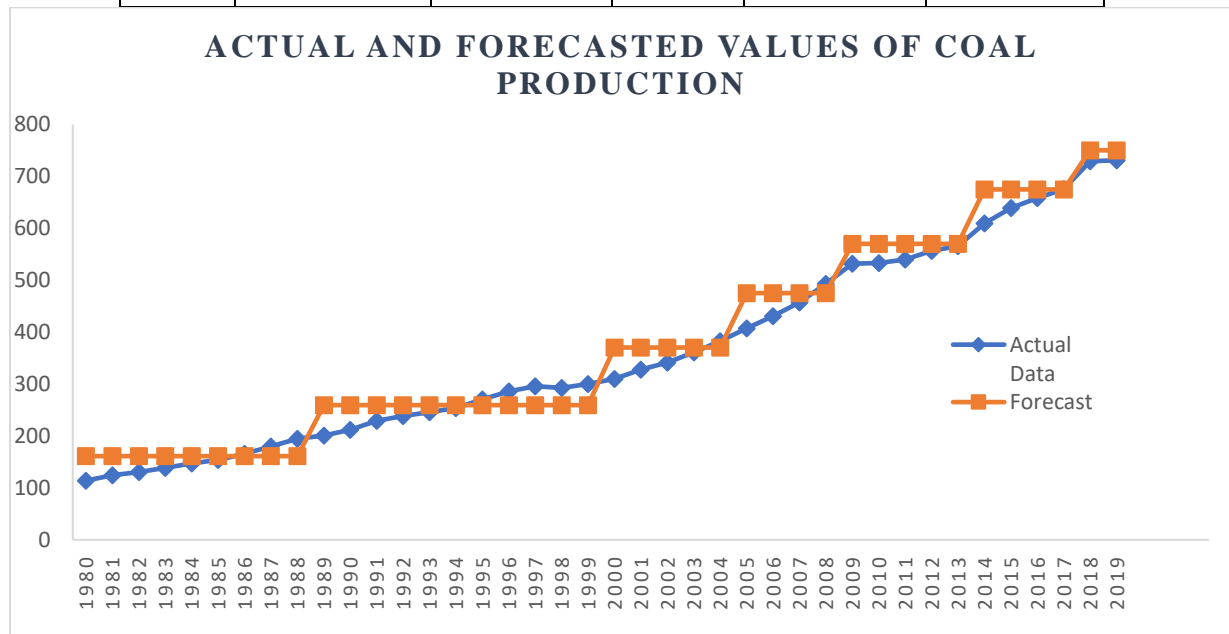


Fig 1. Fuzzy time series forecasting of coal production

Table 5: AMSE

	Srivastava and Singh's Refined Arithmetic Method
MSE	10,532.9457

8. Conclusion

This paper presents the Srivastava and Singh's refined arithmetic model for fuzzy time series forecasting. This method has been implemented on the historical time series data of coal production of India. The Mean Square Error (MSE) of Srivastava and Singh's refined arithmetic method is 10,532.9457. We compared this method to Chen's Arithmetic model, The Mean Square Error (MSE) of the Chen's Arithmetic model is 64968.17314. Therefore, Srivastava and Singh's refined arithmetic method has a higher accuracy rate.

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Edge Domination in Fuzzy Magic Graphs

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ABSTRACT

Let $\Psi = (V, \tau, \mu)$ be a fuzzy magic graph. A fuzzy magic graph Ψ is said to be an edge dominating fuzzy magic graph if for every $e_j \in E(\Psi) - F'$ then there exists $e_i \in F'$ such that (i) $\mu(u, v) < \min(\tau(u), \tau(v))$ for all $e_i \in E(\Psi) - F'$ and $e_j \in F'$, where F' is the edge dominating fuzzy magic set (ii) $\tau(u) + \tau(v) + \mu(u, v) < 1$. In this paper, edge dominating fuzzy magic sets, edge dominating fuzzy magic number are introduced and its basic characters are discussed.

Keywords: Edge Dominating Fuzzy Magic Sets, Edge Dominating Fuzzy Magic number

1. Introduction

In 1736, the concept of graph theory was first introduced by Euler. The concept of domination in a recent year becomes a subject of interest for many researchers due to the immense application to other field. In 1973, Kaufmann gave the first definition of a fuzzy graph which was based on Zadeh's Fuzzy Relations. In 1975, Rosen field introduced the idea of fuzzy graph. The concepts of edge domination in graphs are introduced by Mitchell and Hedetniemi. A fuzzy graph is the generalization of crisp graph. A fuzzy graph structure is an extension of a fuzzy graph. Characteristics of edge domination in graphs are obtained by Arumugam and Velammal.

2. Preliminaries

A subset D of V is said to be a dominating set of G if every vertex not in D is adjacent to at least one vertex in D . The cardinality on minimum dominating set of a graph G is denoted by $\gamma(G)$ [1]. Let U and V be two sets. Then ρ is said to be a fuzzy relation from U into V if ρ is a fuzzy set of $U \times V$. Let G be a simple graph. Then a graph $G = (\sigma, \mu)$ is called a fuzzy graph on G if $\sigma : V \rightarrow [0, 1]$ and $\mu : E \rightarrow [0, 1]$ for all $xy \in E$, we have $\mu(x, y) \leq \min(\sigma(x), \sigma(y))$. The fuzzy set $\sigma(V)$ is called the fuzzy vertex set of G and $\mu(E)$ is called the fuzzy edge set of G [2]. The edge domination number $\gamma'(G)$ is the minimum cardinality among all minimal edge dominating set. The bipartite graphs with equal edge domination number and maximum matching cardinality are characterized by Dutton and Klostermeyer

[3]. A Fuzzy Graph $G = (\sigma, \mu)$ is called a *fuzzymagic graph* if there are two bijective functions $\sigma : V \rightarrow [0, 1]$ and $\mu : V \times V \rightarrow [0, 1]$ with restricted the conditions $\mu(u, v) < \sigma(u) + \sigma(v) \leq 1$ for all $u, v \in G$ [4]. An arc (u, v) of a fuzzy graph $G = (\sigma, \mu)$ is called an effective edge if $\mu(u, v) = \min(\sigma(u), \sigma(v))$ and effective edge neighborhood of $u \in V$ is $N_e(u) = \{v \in V : (u, v) \text{ is effective}\}$. A subset D' of $E(G)$ is called an effective edge dominating set if for every $e_j \in E(G) - D'$ there exist $e_i \in D'$ such that e_i dominates e_j [5].

3. Main Results

Definition 3.1. Let $\Psi = (V, \tau, \mu)$ be a fuzzy magic graph. A fuzzy magic graph Ψ is said to be an *edgedominatingfuzzymagicgraph* if for every $e_j \in E(\Psi) - F'$ then there exists $e_i \in F'$ such that (i) $\mu(u, v) < \min(\tau(u), \tau(v))$ for all $e_i \in E(\Psi) - F'$ and $e_j \in F'$, where F' is the edge dominating fuzzy magic set (ii) $\tau(u) + \tau(v) + \mu(u, v) < 1$.

An edge dominating set of a fuzzy magic graph with minimum number of edges is called a *minimum edge dominating set*. Edge dominating fuzzy magic number $\gamma'_{dfm}(\Psi)$ is the sum of the membership values of the edges of a minimum dominating set.

Example 3.2. Consider $V = \{v_1, v_2, v_3, v_4, v_5, v_6\}$ and $E = \{e_1, e_2, e_3, e_4, e_5, e_6\}$ where $e_1 = v_1v_2, e_2 = v_1v_3, e_3 = v_2v_3, e_4 = v_3v_4, e_5 = v_4v_5, e_6 = v_4v_6$. Define $\Psi: (\tau, \mu)$ by $(v_1) = 0.1, \tau(v_2) = 0.2, \tau(v_3) = 0.3, \tau(v_4) = 0.4, \tau(v_5) = 0.5, \tau(v_6) = 0.6, \mu(v_1v_2) = 0.01, \mu(v_2v_3) = 0.03, \mu(v_1v_3) = 0.02, \mu(v_3v_4) = 0.04, \mu(v_4v_5) = 0.05, \mu(v_4v_6) = 0.06$.

Theorem 3.3. For a cycle C_n , the number of edge dominating set and the number of edge dominating fuzzy magic set are equal.

Proof. Let $G = C_n$ and $V(G) = \{v_1, v_2, v_3, \dots, v_n\}$ and $E(G) = e_i e_{i+1}$ where $i = 1, 2, \dots, m - 1$. Each e_i is adjacent with at least two edges. Thus, each element in D' has at least two neighbour in $E(G) - D'$.

Therefore, the number of edge dominating set of $G = [n/3]$ where $n \geq 3$ (1)

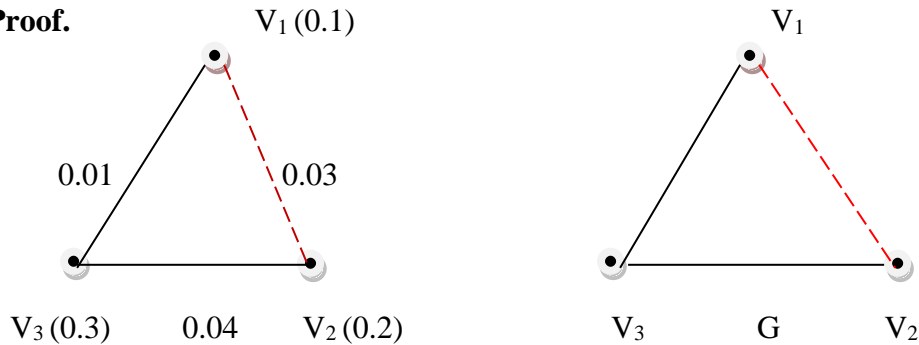
Next, consider the fuzzy magic graph $\Psi = C_n$ has the vertex set $V(\Psi) = \{u_1, u_2, u_3, \dots, u_n\}$ and $E(\Psi) = e_i e_{i+1}$, where $i = 1, 2 \dots m - 1$. The membership value of the edge must be lesser than the minimum of membership value of the adjacent vertices. Let $F' = \{e_1, e_3, e_5, \dots, e_{n-1}\}$ is the edge dominating fuzzy magic set. Thus, each element in F' has at least two neighbour in $E(\Psi) - F'$. Therefore F' is the minimum edge

dominating set of Ψ . And the number of edge dominating set of $\Psi = \lfloor n/3 \rfloor$ where $n \geq 3 \dots \dots \dots (2)$

From (1) and (2) we get, the number of edge dominating set and the number of edge dominating fuzzy magic set are equal.

Result 3.4. Let Ψ be an edge dominating fuzzy magic graph and G be a graph. Then $\gamma'_{dfm}(\Psi)$ and $\gamma'(G)$ are different.

Proof.



In fig (a), $\gamma'_{dfm}(\Psi) = 0.03$

In fig (b), $\gamma'(G) = 1$

Hence $\gamma'_{dfm}(\Psi) \neq \gamma'(G)$

Theorem 3.5. For any graph, $\gamma(G) > \gamma'_{dfm}(\Psi)$

Proof. Let us assume $\gamma(G) = \gamma'_{dfm}(\Psi)$. Since, the domination number is always greater than or equal to one. That is, $\gamma(G) \geq 1 \dots \dots \dots (1)$

By the definition of edge dominating fuzzy magic graph, that is $\gamma'_{dfm}(\Psi) < 1 \dots \dots \dots (2)$

From (1) and (2) $\gamma(G) \neq \gamma'_{dfm}(\Psi)$. This is a contradiction to our assumption. Therefore $\gamma(G) > \gamma'_{dfm}(\Psi)$.

Theorem 3.6. For a helm graph the number of edge dominating fuzzy magic set

$$\begin{cases} \left\lfloor \frac{n}{2} \right\rfloor & \text{if } n \text{ is odd where } n \geq 3 \\ \frac{n}{2} + 1 & \text{if } n \text{ is even where } n \geq 6 \end{cases}$$

Proof. Let $\Psi = H_n$ be a fuzzy magic graph with $2n + 1$ vertices and $3n$ edges. The helm graph is the graph obtained from a wheel graph by adding a pendant edge to each node of the cycle. Here we have two cases.

Case (i): n is odd

For $n = 3$, $F' = \{e_i, e_j\}$ where $i, j = 1, 2, 3$ and $i \neq j$ is the minimum edge dominating fuzzy magic Set of Ψ so that the number of edge dominating fuzzy magic set is 2.

Let $\left\lfloor \frac{n}{2} \right\rfloor = k$, next to prove the number of edge dominating fuzzy magic set $\left\lfloor \frac{n}{2} \right\rfloor$, where $n \geq 5$.

On the contrary, suppose that the number of edge dominating fuzzy magic set is $\left\lfloor \frac{n}{2} \right\rfloor - 1 = k - 1$. Then there exist $e_i \in F'$ such that $e_j \notin E(\Psi) - F'$ which is a contradiction. Therefore, the number of edge dominating fuzzy magic set is $\left\lfloor \frac{n}{2} \right\rfloor$.

Case (ii): n is even

When $n = 6$, the number of edge dominating fuzzy magic set is 4.

When $n = 8$, the number of edge dominating fuzzy magic set is 5.

Continuing like this the number of edge dominating fuzzy magic set is $\frac{n}{2} + 1$ where $n \geq 6$.

Therefore, the number of edge dominating fuzzy magic set is

$$\begin{cases} \left\lfloor \frac{n}{2} \right\rfloor & \text{if } n \text{ is odd where } n \geq 3 \\ \frac{n}{2} + 1 & \text{if } n \text{ is even where } n \geq 6 \end{cases}$$

Observation. 3.7. For a helm graph H_4 , the number of edge dominating fuzzy magic set is equal to 2

- For a path P_n , the number of edge dominating fuzzy magic set is

$$\begin{cases} \frac{n}{3} & \text{if } n \equiv 0(\text{mod}3) \text{ and } n \geq 3 \\ \left\lceil \frac{n}{4} \right\rceil & \text{if } n \equiv 1(\text{mod}3) \text{ and } n \geq 4 \\ \left\lceil \frac{n}{5} \right\rceil + 1 & \text{if } n \equiv 2(\text{mod}3) \text{ and } n \geq 5 \end{cases}$$

4. Conclusion

The paper extensively covers the fundamental properties of the subject. The potential applications of this research suggest its relevance to standard graphs in future studies.

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Implementation of Neural Network Algorithms in AI Based Pattern Recognition

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ABSTRACT

This paper is the one of the expansion and implementation of neural network algorithm to Artificial Intelligence (AI) techniques for pattern recognition. A neural network is connections of biological neurons, also called a biological neural network, or a network of artificial neurons or nodes in the case of an artificial neural network. This paper briefly explain how neural network algorithms are implemented in AI to improve the learning methods used in existing algorithm in AI based pattern recognition. Pattern recognition is derived from machine learning that used in data analysis to find unknown incoming patterns and known patterns are trained. This implementation gives good result when comparing to the existing algorithms used in AI techniques. In this paper, we implemented Gradient Descent Algorithm, Newton's Method Algorithm, and Levenberg-Marquardt algorithm to recognize unknown patterns.

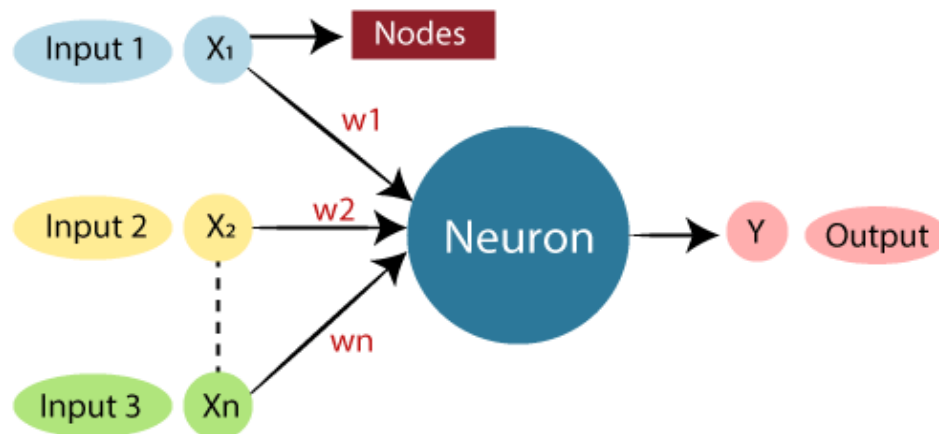
Keywords: Artificial Intelligence, Neural Network, Biological Network, Neurons, Machine Learning

Introduction

Neural networks, also known as Artificial Neural Networks (ANNs) or Simulated Neural Networks (SNNs), are a subset of machine learning and are at the heart of deep learning algorithms. Their name and structure are inspired by the human brain, mimicking how biological neurons signal to one another. Neural networks rely on training data to learn and improve their accuracy over time[1]. However, once these learning algorithms are fine-tuned for accuracy, they are powerful tools in computer science and artificial intelligence, allowing us to classify and cluster data at a high velocity. Tasks in speech recognition or image recognition can take minutes versus hours compared to manual identification by human experts. Similar to the human brain which has neurons interconnected to one another, artificial neural networks also have neurons that are interconnected to one another in various layers of the networks. These neurons are known as nodes [3].

Methodology

The block diagram shows the practical way neural networks work with the human brain of Figure 1.1. An Artificial neural network is usually a computational network based on biological neural networks that construct the structure of the human brain [2]. Similar to a human brain has neurons interconnected to each other, artificial neural networks also have neurons that are linked to each other in various layers of the networks.



1.1 Neural Network with Artificial Intelligence

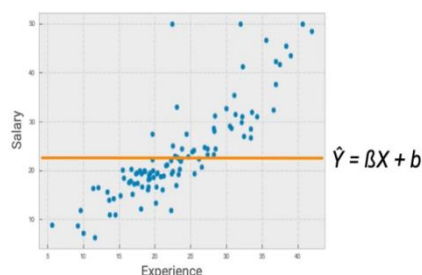
i) Gradient Descent Algorithm with Artificial Intelligence

In neural Network Algorithm, Gradient descent is an optimization algorithm that works iteratively to find the model parameters with minimal cost or error values. Gradient descent is a first-order iterative optimization algorithm for finding a local minimum of a differentiable function. Gradient Descent in Linear Regression which needs to find the cost/error, distance, and updated parameters [5].

$$Y = \beta X + b$$

Parameters: β and b

- $\beta \rightarrow 0$
- $b \rightarrow \text{Mean of independent Variable}$



Error: Mean squared error is the average squared difference between the estimated values and the actual value. (formula)

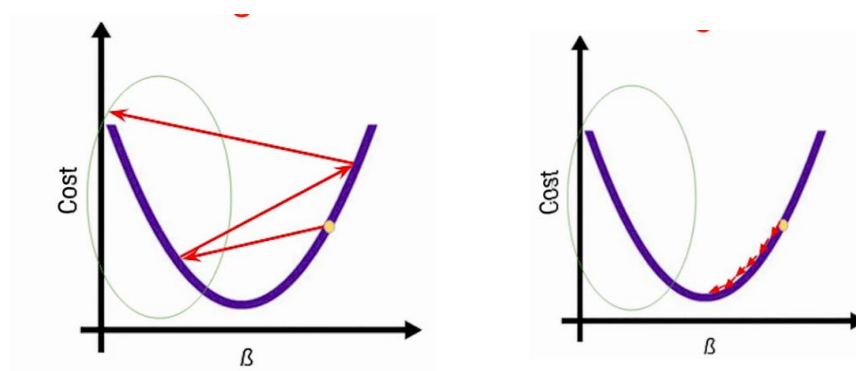
$$J = \frac{\sum_{i=1}^n (\hat{Y}_i - Y_i)^2}{n}$$

Update Parameter: (formula)

$$G_{\beta} = \frac{\partial(J)}{\partial \beta} = \frac{2 \sum_{i=1}^n (\beta X_i + b - Y_i) X_i}{n} \quad \beta = \beta - \alpha G_{\beta}$$

Let us consider a man throwing a ball to the basket with a random parameter, if it fails then automatically the function updates the parameters using another random value. In this way, they find the exact destination of the basket.

On the other hand, if the learning rate is too small, the model will take too much time to reach the minimum cost.

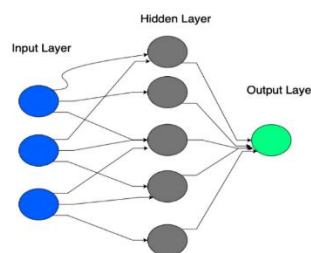


The Learning gradient from High Learning to Low Learning.

Hence, the gradient descent algorithm is used to learn the cost and parameters with the different parameters of the different times in the updated parameters. This Gradient Descent Algorithm gives 85 percentage of accuracy for the applied patterns used in hand written applications [2].

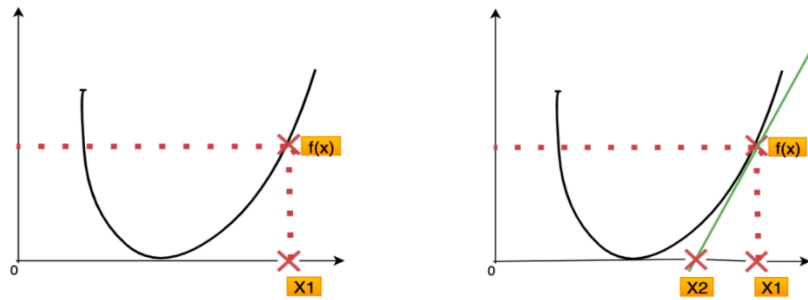
ii) Newton's Algorithm with Artificial Intelligence

Newton's method uses the second derivative. This method aims to find better training directions by using the second derivatives of the loss function.



To find the root it first starts by picking a random point (y_1) and find out what the function evaluates at that value $f(y_1)$

Slope = $f'(y = y_1)$ Using the slope of the line we can find the second point (y_2)



The next point is y_2 , to find it is going to be y_1 minus the Δx or the ratio between

$$\frac{f(x_1)}{f'(x_1)}$$

$$\text{Slope} = \frac{\text{rise}}{\text{run}} = \frac{f(x_1)}{\Delta x}$$

$$\Delta x = \frac{f(x_1)}{\text{slope}}$$

$$\text{slope} = f'(x_1)$$

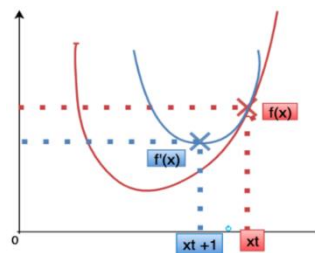
Now to find the next point y_3 the process can be repeated

$$\Delta x = \frac{f(x_2)}{f'(x_2)}$$

$$x_3 = x_2 - \Delta x$$

Newton's method when applied to Optimization gives a way to find the minimal or maxima.

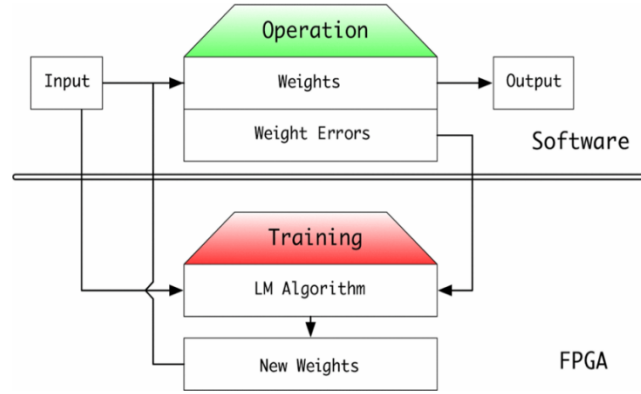
Instead of finding the derivative of the $f(y)$ it tries to find the one at the derivative of the function evaluated at Y .



Hence, the Newton method algorithm is used to find the parameters with different values and to find another slope with the previous value to train the machine of AI an equal number of times to find the best destination. This Newton's algorithm gives 85.5 percentage of accuracy for the applied patterns used in hand written applications [4].

iii) Levenberg-Marquardt algorithm with Artificial Intelligence

The Levenberg-Marquardt algorithm is used to work specifically with loss functions defined by a sum of squared errors. It works without computing the exact Hessian matrix. Instead, it works with the gradient vector and the Jacobian matrix.



Consider a loss function which takes the form of a sum of squared errors,

$$f = \sum_{i=1}^m e_i^2$$

Here $(X \rightarrow n)$ is the number of training samples.

The loss function as that containing the derivatives of the errors concerning the parameters,

$$\mathbf{J}_{i,j} = \frac{\partial e_i}{\partial \mathbf{w}_j},$$

Where $(X \rightarrow n)$ is the number of samples in the data set, and $(Y \rightarrow m)$ is the number of parameters in the neural network.

Note that the size of the matrix is $(X \rightarrow n, Y \rightarrow m)$.

We can compute the gradient vector of the loss function as

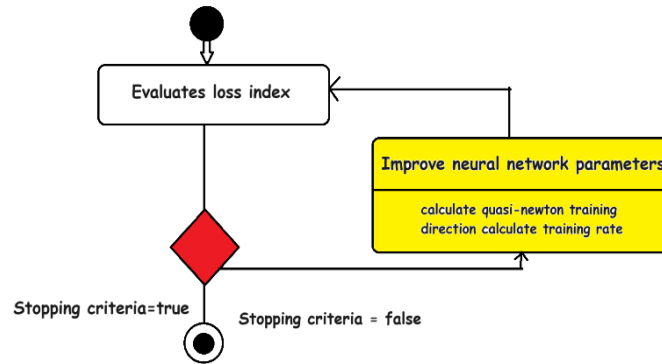
$$\nabla f = 2\mathbf{J}^T \cdot \mathbf{e}$$

Now we define the parameters for improvement of the process with the Levenberg-Marquardt algorithm.

$$\mathbf{w}^{(i+1)} = \mathbf{w}^{(i)} - (\mathbf{J}^{(i)T} \cdot \mathbf{J}^{(i)} + \lambda^{(i)} \mathbf{I})^{-1} \cdot (2\mathbf{J}^{(i)T} \cdot \mathbf{e}^{(i)})$$

The parameter (λ) is initialized to be large, so the second updates are smaller than first step in the gradient descent direction [8].

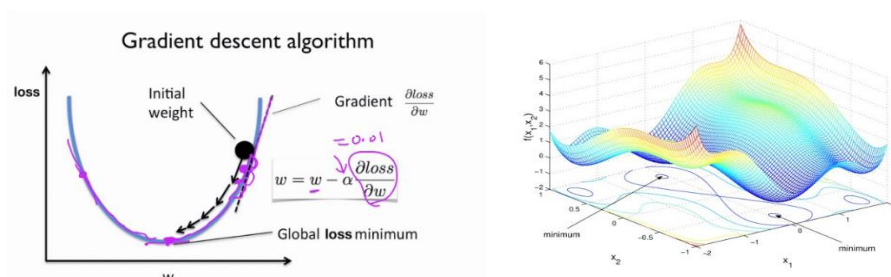
If any iteration results in a failure, then (λ) is increased by some factor. Otherwise, (λ) is reduced as the loss decreases, so the Levenberg-Marquardt algorithm approaches the Newton method. This process typically accelerates the convergence to the minimum.



Hence, It is faster than the gradient descent and the Newton method, the exact Hessian must not be computed and inverted. Also, the Jacobian matrix becomes enormous for big data sets and neural networks, requiring much memory. This Levenberg-Marquardt Algorithm gives 86.8 percentage of accuracy for the applied patterns used in handwritten applications [7].

Comparing between Gradient Descent Algorithm and Levenberg-Marquardt:

In neural Network Algorithm, Gradient descent is an optimization algorithm that works iteratively to find the model parameters with minimal cost or error values. The Levenberg-Marquardt algorithm is used to work specifically with loss functions defined by a sum of squared errors. It works without computing the exact Hessian matrix. [10]



we can write our loss function for the single row as below:

$$J(w, b) = \frac{1}{n} (y_p - y)^2$$

To find the optimal value of weight w and bias b , we partially differentiate concerning w and b . This is also said that we will find the gradient of loss function $J(w, b)$ for w and b to find the optimal value of w and b . Levenberg-Marquardt considering a loss function that takes the form of a sum of squared errors,

$$f = \sum_{i=1}^m e_i^2$$

Here, the number of training samples are $(X \rightarrow m)$

We can define the Jacobian matrix of the loss function as that containing the derivatives of the errors concerning the parameters,

$$\mathbf{J}_{i,j} = \frac{\partial e_i}{\partial \mathbf{w}_j},$$

Where $(X \rightarrow m)$ is the number of samples in the data set, and $(Y \rightarrow n)$ is the number of parameters in the neural network.

Note that the Jacobian Matrix size is $(X \rightarrow m, Y \rightarrow n)$. We can compute the gradient vector of the loss function as

$$\nabla f = 2\mathbf{J}^T \cdot \mathbf{e}$$

The following expression defines the parameters to improve the process with Levenberg-Marquardt algorithm[4].

$$\mathbf{w}^{(i+1)} = \mathbf{w}^{(i)} - (\mathbf{J}^{(i)T} \cdot \mathbf{J}^{(i)} + \lambda^{(i)} \mathbf{I})^{-1} \cdot (2\mathbf{J}^{(i)T} \cdot \mathbf{e}^{(i)}).$$

The parameter (λ) is initialized to be large, so the first updates are small steps in the gradient descent direction.

If any iteration results in a failure, then (λ) is increased by some factor. Otherwise, (λ) is reduced as the loss decreases, so the Levenberg-Marquardt algorithm approaches the Newton method. This process typically accelerates the convergence to the minimum.

Hence, Levenberg-Marquardt is an optimization method, while backdrop is just the recursive application of the chain rule for derivatives and, intuitively does this: when Gradient descent is far from a local minimum, it ignores the curvature of the loss and acts as a gradient descent. From the above rules, the gradient descent is the fastest algorithm than the Levenberg Marquardt.

Advantages

1. **Using a Large number of Datasets:** Artificial neural networks can learn and create from large amounts of data. They can be trained using large datasets and this allows them to make predictions and decisions based on patterns of the Algorithm of Gradient, Newton, and Levenberg–Marquardt [6].
2. **Handling the Missing Data of Datasets:** Artificial neural networks are that they remain functional despite noise or errors in data. This makes them suitable in situations with noisy, incomplete, or corrupted data on the three-based Algorithm.
3. **Automation and Multitasking of the Large Datasets:** They can extract features from data. This eliminates manual feature editing. They can also be trained to handle multiple tasks simultaneously. This makes them useful in advanced AI applications with the neural network [8].
4. **Fast and Parallel ProcessingDatasets:** Artificial intelligence networks can be optimized and used efficiently on hardware accelerators or dedicated AI processors such as graphic processing units and artificial intelligence accelerators for fast and parallel processing of the Gradient and Newtons Algorithm with the Artificial Intelligence.

Disadvantage

1. **Requires Huge Amounts of Datasets:** ANNs also come from the fact that they can learn from large training data. Obtaining huge amounts of datasets can be difficult and time-consuming for the different Algorithm of the neural networks.
2. **High Computational Requirements of Data:** Artificial neural networks are that they need capable hardware components such as central processors or dedicated AI accelerators, large storage spaces, and sizeable random-access memory with Newton's Algorithm [9].
3. **Hardware Requirements of Datasets:** For beginners or those on a tight budget, might be one of the obstacles of neural networks. Moreover, it can also mean that one has to invest in supplementary things more than the main component of the process. Thus, artificial neural networks can be a bit problematic when it comes to their hardware setting, organization, and placement.

4. **Minimal Control of datasets:** This refers to the minimal control that the trainers have over the actual performance and overall functioning of the ANN. From probable value to the unknown steps of working, artificial neural networks are pretty much concealed in their actual structure [11]. This can mean that not much external influence or control can be exerted on these networks to run them at the user's convenience.

Conclusion

This research paper aims to develop the Algorithm for the Neural Network combined with Artificial Intelligence to perform different actions to train the machine with the high-level to low-level performance of the system in Artificial Intelligence. The new proposed system is combined with the neural network to train the machine with highly precise to give exact results. The machine using the neural power algorithm with Artificial Intelligence Techniques successfully trained. These algorithms give better accuracy than existing algorithms used in AI based pattern recognition.

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Inscriptions and Copper Plates of Nellaiyapper Temple at Tirunelveli – A Study

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ABSTRACT

The Chola supremacy came to an end in the Pandya country by the emergence of later pandya rulers like War. Sundrarapandya I. He and his successors paid more attention than ever in the socio – religious activities of Thirunelveli region. There are a number of stone inscriptions in the temple. The most important of them are those Veerapandiyan who regained about 950 and those of Rajendran I and Kulothunga Chola I. The inscriptions of Maravarma Sundara Pandiyan refer to the Lord as "Woodayar" and "Wodeyanayanar" and the Goddess as "Nachiar". From the inscriptions of Kulasekkara Pandiyan we learn that he defeated the Chera, Chola and Hoysala kings and built the outer walls of the temple with the war booty. Nellaiappar temple is spread over 14 acres.

Keywords: Woodayar, Stone inscriptions, Pandya rulers, Chola rulers, Hoysalas

Introduction

There are more than Fifty inscriptions in this temple. Many of these inscriptions are very ancient period. They are inscribed in scripts such as cursive, Grantha Tamil, Kannada and Telugu. The oldest of the inscription dated to the second regnal year of the Pandya King named Virapandian (946 - 966 A. D). VeeragaliMarthandavarman 1546 AD he built the Music Pillar Hall. The lord here is SwamiiNellaiappar Goddess GandhimatiAmman. The main Plant is bamboo it was musical instrument here is Savangi.

Nellaiyapper Temple Inscription

During the reign of ArikesariMaravarman alias NinrasirNedumaran (640 - 6470 A.D.) SaivasaintThiru Gana sambandar visited the Tirunelveli and sung in Praise of Tirunelveli. Virapandya was (946 - 966 A.D) the son of Rajasimha II (900 - 946) fourth regnal year 950 A.D and seventh regnal year (953 A.D). Inscriptions found on the west wall and north wall of the MulaMahalingar Shrine in the Nellaiyapper temple seems to record a gift to the Permanadigal alias Nellaiyapper temple by Manikkam Battelakon of idaikkarai in Mungudinadu in memory of his mother Ettinili and Vidaiyangadival alias TikaiyenTanichchai of TavalurTuraikudi in Mungudinadu granted fifty sheep for burning perpetual lamp in the Nellaiyapper temple. The sheep were received by a Padaittalaivan

called ChattenTirunelveli withChendanBataranBrahmapriyapperunai being his surety. The above said inscription mentioned Tirunelveli and Nellaiyapper temple were administered by the Padaittalaivan.

Rajendra Chola Ist, (1012 -1044) eighth regnal year 1020 A.D. inscription found on two Pillars of the Mandapa on the South side of the large shrine in the Nellaiyapper temple records a new arrangement made the AdhikerikalBirammaSrikilar who was enquiring into the services in the temple of Tirunelveli for the supply of Camphor, Sandal etc., to the temple by the ValadinJeyerof the placewho had the Kani rights of some of temple lands in Kannanur.The Velanjeyer were required to pay 22 Kasu perma per day towards the due Chirappilkudimai on the lands.

Kulotunga Chola Istascending year 1070 A.D. inscription found on the north wall of the Sastralinga shrine on the north side of the second prakara in the Nellaiyapper temple records arrangements to reclaim some portions of lands inTirukunrattur a devadana of Tirunelveli Udaiyar temple which remained uncultivated. The lands were made over to the Sabha UttamacholaChaturvedimangalam in Kilkalakkurram for cultivation. The Sabha was required to the temple four Kasu and four Kalam of Paddy per crop per ma.Eighteen regnal year 1196 A.D. inscription of Kulottunga III found on a broken pillar lying in the second prakara of Nellaiyapper temple registers a gift of the tax of fifteen Kasu accruing from certain lands in Ariyantaltan alias Valaiyakranallur in Amudagunavalanadu which had been granted for worship in the temple of Tirunelveli Udaiyar by Vidivitankanselman alias Tyagavinodamuvendavelan the headman of Palaiyur in Tiruvarurkurram a sub-division of Geyamanikkavalanadu.

Jatavarma Kulasekhara pandyaIst ascending year 1190 A.D. inscription found on the last wall of the second Prakara of the Nellaiyapper temple. States that the king built the high prakara wall of the temple of Siva who had sprung from bamboo, from the booty obtained after defeating, Kerala, Chola and Hoysala kings.

MaravarmasundarapandyaIst (1216 -1238) second regnal year 1217 A.D. inscription found on the inside wall of the third Prakara of Nellaiyapper temple registers a gift of six ma of land and some paddy to seven men from the addukkalaipuram lands in the Padappaikurichi in Kilkalakurram belong to the temple at Tirunelveli. The same king eighth regnal year 1223 A.D. inscription found on the north wall of the third prakara of the Nellaiyapper temple registers a gift of three and half ma of land on behalf of Alagiyapillai alias Kalingarayer of Ilagudi to the two Brahmins as adyayenaVirutti for chanting Vedas during the service called Konchipuram then dam Sandhi instituted in the temple of Tirunelveli Udaiyar.

Maravarma Sundara pandya II (1238 to 1253) third regnal year 1240 A.D. inscription found on the east wall of third Prakara outside of the Nellaiyapper temple registers a gift of cows and two ma of land in Kannanur alias Raviventrachaturvedimangalam in Kilvembunadu to Sundarapandya Brahmadarayan for providing milk on the eight occasion of worship in the temple Tirunelveli Udayanarayanar during the service instituted by Chedirayer.

Jatavarman alias Tribhuvanachakravartin Virapandya II (1253 - 1268) co-ruler of Jatavarmasundarapandya Ist (1251 - 1268) fifth regnal year 1258 A.D. Inscription found on the outside of the west wall of the second prakara of Nellaiyapper temple registers provision for oil for an evening light to the shrine of Narpatoenayirapillaiyar at Villavarayanallur in Melvembunadu.

Rajagopura Tirupani Inscription

This inscription Located in front of the Nellaiappar temple, the script of Tamil during the period 17th&18th century, not mention any collector period or Name. In this inscription details about Graceful Goddess Gandhimathi blesses Nellaiappar Temple entry at the gate located.

Gandhimati Ambal Golden Robe Ceremony Inscription

It was located in Ambal shrine on the facade the script of Tamil during the period of 18th&19th century not mention writer Name. Inscription details about in front of Arthamandapam of Ambal shrine in this temple.

Kumbabhishek inscription

In this script was Tamil / Tamil - Brahmi, century not mention during the period of Recent period. Inscription details it Located on the right side of the front of Unchal Mandapam.

Pradosha Command Inscription

The command inscription Located Ambal shrine Internal Near Utsawarsannadi in Prakaram, script of Tamil during the period 20th&21th century, not mention collector period or Name. Inscription details about Graceful Nellaiappar Arultharum Nagar Ambal shrine of this temple Amman first prakaram near Utsawarsannadi is the Pradosha command inscription.

Gopuram Inscription

The gopuram of this temple is 850 feet long and 756 feet wide. Sangili Mandapam built on 1647 by vadamalaiyappapillayan connects the Ganthimathi Amman and Nellaiyappar temples. The composite columns of Virabhadra holding sword and horn are found be additions of the Vijayanayagara kings during the early 1500s. Similar columns of Virabhadra are found in Adikesava Perumal Temple at Thiruvattaru, Meenakshi Temple at Madurai, Kasi

Viswanathar temple at Tenkasi, Krishnapuram Venkatachalapathy temple, Ramanathaswamy Temple at Rameswaram, Soundararajaperumal temple at Thadikombu, Srivilliputhur Andal temple, Srivaikuntanathan Perumal temple at Srivaikuntam, Avudayarko Vaishnava Nambi and Thirukurungudi Valli Nachiar temple at Thirukkurungu. Tirunelveli also is one of the five places where Lord Siva is said to have displayed dance and all these places have stages or ambalams.

Shrine Inscriptions

There are inscriptions about Nellaiappar Temple, this temple is considered as one among the 14 Saiva centers sanctified by the Devaram hymnists in Pandya country. This temple copper plate exists one among the five divine halls (Pancha Sabhas) of Siva in Tamilnadu, where Lord Nataraja played his Anantha Thandava. This spacious temple consists of records from 8th century A.D to 19th century A.D. Vatteluthu, Tamil and Grantha scripts have been applied for engraving records in different periods. Land donations, cattle donations for lighting perpetual lamps, the role of oil mongers, land endowments as Bhatta Vritdhi, and for musicians are all well preserved in the inscriptions. The role of Brahmi Mahashabas, Kumbabisheka ceremonies conducted at different times, their actual expenditure details are also vividly given. Different 'Santhi' workshops instituted by the kings on their natal star, donations for their maintenance and the temples development during the Pandya rule are all well documented in the records.

Some of the records of this temple are composed in a beautiful verse form. Different iconographic forms of Siva like Lingothbhava, Bhikshadana are mentioned in these verses. Quite interestingly one chieftain Thadkanni Chirurudaiyan Uyyaninraduvan Gurukulatharaiyan has written a verse. He declares here that he had donated enough quantity of land for the Lord Siva, so that he need not go on begging as a Bhikshadanamurthy with a begging bowl (Kapala). This verse is composed in the sense of satire which is also found in a record of Thiruthankal Siva temple (Viruthunagar Dt.) of the same chieftain. This chieftain has played a crucial role in the administration during the period of Mar. Sundara Pandya I.

Another interesting record is found in front of the Shanmuka shrine in the outer western prakara of this temple. It reveals the musical notes (Thalanka Pramanam) introduced by one Picchandi Annavi, a resident of Pasuvanthanai Village during 1870 A.D. These notes are engraved on a well blossomed lotus flower so neatly carved on the floor.

Nellaiyappar temple was extended by new mantapas, new shrines and prakaras since the time of middle Cholas. These activities are well attested by the records engraved on the pillars and walls bearing these mantapas and shrines. So, the Architectural history can be

easily traceable by these records. One record reveals the donation made by one dancing girl from Madurai Meenakshi Temple who was also honoured by the title “*Thalaikoli*”. From these evidences the great name and influence enjoyed by this temple in the whole Pandya region can be known.

Pujas Inscription

The palm-leaf record on the other hand, provide more details. The earliest of the available record belongs to 1687 A.D., and the data it furnishes about the various pujas are surprisingly similar to the practices adopted at present.

Festivals Incriptions

Inscriptions found in Nellaiappar temple reveal the endowments given by the kings and the individuals for the conduct of daily offerings and number of festivals connected therein. Amudu and Prasadam are the terms used in the inscriptions for the holy food. The food is offered to the God thrice in a day, the morning, mid-day, and the early hours of the night. Extensive provisions for the food offerings are found engraved in the inscriptions, not only for the daily routine but also on various festive occasions. In fact, many inscriptions give a lengthy list of details regarding the different proportions of the several provisions required for different kinds of food offerings.

Copperplates are Message Vaults

Nallaiyappar Gandhimati Amman Temple Copperplate grant of land to Uchanadi Charitable Order

In 1630, NayanarNelveli Natha Swami Ormaman of Tirunelveli Lower Vemba Country gave a price deed to the Uchhanadi Aramvalartha Command of Kudanadu Vannikuttatu Thalivamar. From this Cheppu charter it is known that Tirunelveli was known as Vembanadu under the name of Swami Nallaiappar as Nelveli Nadar and Gandhimati as Amman formaman. The ‘Kudanadu’ mentioned in it is worth research. Like all the Copper Plates those who practice this dharma mentioned in the final part will get the Power of making many crorss of Shivalingams on the banks of the Ganges and the strength of many AsvamedhaYagyas and those who have Committed a crime to this Dharma will go to the dosa of Killing a cow on the banks of the Ganges. Deeply emphasizes the idea of maintenance.

Copper Plate Regarding of Sarve to Tirupudaimarudur Narumpoonathaswarmy

In 1640, Viswanatha Nayak, Chokkanatha Nayak, Muthuveerappa Nayar, Vijayrenga Chokkanatha Nayak, Talavai Nachiappar to perform pooja to Tirupudaimarudur Narumpoonatha Sami. A Copper plate bearing the command of sarva Manipam by

Thiruenkata Nayak, Vadamalayappa Pillaiyan and Ananta Paramanatha Pillaiyan. From the Word 'Thekellaiyagiar' Which was given by MarutumSoolam and Narumboo Mudrakali, the boundary code used in the land Measurement of that day is known.

Vanji Cherakula Rama Pandyan period Copper Plate

Vanji Cherakula Rama Pandyan a Copper plate in 475 A.D of Nageeswarar Sivagami Amman Udayamarthanda Paying the Deities. The name of the town called Nangeeswaraneri is mentioned in this Charter. This town is Known as Kunnathur (Lower Thiruvengkatanathapuram) Which is the fourth Place in Nagugalaya Talam (Iragu Talam Similar to Thirunageswaram on the banks of the Kaveri). Thiruvengkatanathapuram is also known as Tirunangoil today. It can be assumed from this copper plate that this Thirunangoil may be the Maru of Tirunangeesaneri. This is evident from the names Nageesar and Sivagami Amman mentioned in this Cheppu charter. Also, it is clear from this green care that expressions indicating the size of the face like 'Bengal OsaipadikkuTavali saw the Place and attacked it' and 'Seposaipadikku' were in use in those days.

35 Tala Inscription

There is another tala inscription seen at Nellaiappar Temple Tirunelveli. It is detectable in the outer Praharam of Nellaiappar temple in front of Arumugar Sannidhi. It is found on the floor in front of two Dvarabalaka of Arumugar Sannidhi. It also explains 35 Tala more in detail than Meenakshi Amman temple in Madurai. It is also flower like Chekra with 6 Layers of petals. The Center is found with a star like structure around the six corners of the star Shadanga symbol is engraved. In the next layer the names of shadanga are engraved. In the third layer of seven petals symbols of saptha Tala followed by the names of saptha tala symbol is carved. The fifth layer is engraved with 35 Tala symbol which is followed by 35 tala symbol names. So totally 6 layers are seen. This also belongs to 14th Century A.D.

Literary Mention

TirunanaSambandar and Appar, the 7th Century Tamil Saivite poet Nayanmars, venerated Nellaiappar in ten verses in Tevaram, compiled as the First Tirumurai. Sundarar, an 8th century nayanmars, also venerated idaiyatreeswarar in ten verses in Tevaram, compiled as the Fifth Tirumurai. As the temple is revered in Tevaram, it is classified as Paadal Petra Sthalam, one of the 276 temples that find mention in the Saiva canon. Muthuswami Dikshitar composed one song (Sri Kantimatim) on this song is considered to be a rare song set in the rare raga Hemavathi.

Conclusion

This shrine has more than fifty inscription and most of them are from the ancient time. They're carved in many languages such as Krantham, Tamil, Kannada and Telugu. This temple is praised by ThirugnanaSambandhar. One of the oldest inscriptions of this temple is about the King Cholan Thalai Konda Veera Pandian (BC:946 - 966). It narrates the story of a courtesan who daily gave ghee for lightin lamp. Through this inscription we came to know that God was named as "TirunelveliBhrammapuri Thevar". The inscriptions in the pillars of the temple which belong to the period of Rajendran I (BC: 1012 - 1044) and Kulothugna Chola I (BC:1070 - 1120).In the inscription about Sadayavarmankulothungapandiya to, The Lord Shiva of the temple is being called as 'Tirunelveli Udaya Nayanar' and also the temple has man inscriptions about many famous Kings such as Sundara Pandian (BC: 1216 - 1244) Vikrama Pandian (BC: 1250 - 1276), Veerasomeshwaran (BC: 1238 - 1258), Maravarman Sundara Pandian II, Sadaya Varma Veerapandiya II, Maravaraman Kulasekaran I (BC:1258 - 1308 Constructed the wall), MunthiKottu Veeram AlagiyaPandiaThevan (constructed the PollapillayarSannithi), Parakrama Pandiyan, Veera Sangili Marthanda Varman (constructed the musical pillar mandapam) etc.

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Tourism Development Through the Lemur Beach in Kanyakumari District

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ABSTRACT

Tourism is important and vital for our country. Tourism involves traveling with the specific object of studying, admiring, and enjoying the scenery as well as cultural and historical areas. Sustainable development of Tourism includes mainly the growth rate of domestic and foreign tourists. Lemur beach is a natural as well as historical tourist place of India. Lemur Beach also known as Ayiram Kall Pozhimugam Beach or Ganapathi Puram Beach is a renowned tourist destination located in Ganapathi Puram, a locality in Nagercoil of Kanyakumari district. Lemur Beach is a secluded beach located in the Kanyakumari district of Tamil Nadu, India. The beach is known for its pristine blue waters, soft white sand, and breathtaking natural scenery. Lemur Beach is located in the village of Muttom, which is about 32 km from Kanyakumari town. The beach is accessible by road, and visitors can hire a taxi or take a bus from Kanyakumari town to Muttom village. The nearest airport and railway station are in Trivandrum, which is about 85 km away.⁷ The beach is surrounded by lush green forests and rocky cliffs, providing a stunning backdrop for the blue waters of the Arabian sea. Visitors can enjoy a peaceful walk along the beach, taking in the natural beauty of the area. In this article, we will explore Tourism development through the Lemur Beach in Kanyakumari District in detail.

Keywords: *Lemur Beach, Tourism Development, Kanyakumari District, Coastal Tourism, Ecotourism, Sustainable Tourism, Cultural Heritage*

Introduction

Welcome to the vibrant world of Lemur Beach, a captivating destination nestled in the picturesque Kanyakumari District. As we embark on a journey of tourism development, Lemur Beach emerges as a jewel in the coastal landscape, offering a unique blend of natural beauty, cultural richness, and recreational opportunities. Lemur Beach, situated along the azure shores of the Arabian Sea, boasts pristine sandy stretches and crystal-clear waters that create an inviting haven for tourists seeking a tranquil escape. The beach is named after the Lemur, a fascinating and endangered primate species found in the lush forests nearby, adding an ecological dimension to the tourism experience. Our vision for tourism development at Lemur Beach is rooted in sustainability, community engagement, and the preservation of the area's ecological diversity. We aim to create an immersive experience that not only captivates

visitors but also promotes responsible tourism practices. This development initiative encompasses a range of activities and amenities designed to cater to diverse interests. Adventure enthusiasts can indulge in water sports like snorkelling, kayaking, and paddle boarding, while nature lovers can explore the rich biodiversity of the surrounding areas through guided eco-tours and bird watching excursions. Cultural immersion is also a key focus, as the Kanyakumari District is steeped in history and tradition. Local artisans and performers will have the opportunity to showcase their crafts and talents, providing tourists with a deeper understanding of the region's cultural heritage.

To ensure the sustainability of our tourism efforts, we are committed to implementing eco-friendly practices, waste management programs, and community-driven initiatives. Through collaborations with local businesses and residents, we aim to create a positive impact on the livelihoods of the community while preserving the natural beauty of Lemur Beach for generations to come. As we embark on this exciting journey of tourism development, Lemur Beach stands as a testament to the harmonious coexistence of nature, culture, and responsible tourism. The Lemur Beach is a hidden gem in the Kanyakumari district, offering visitors a unique and peaceful escape from the crowded tourist spots. The natural scenery, wildlife, and water sports make it a must-visit for anyone traveling to the area. Join us in discovering the enchanting allure of Lemur Beach and contribute to a sustainable and enriching tourism experience in the heart of Kanyakumari District.

Brief History of Lemur Beach

Lemur Beach Also Known as Ayiram Kall Pozhimugam Beach or Ganapathi Puram Beach Is a Renowned Tourist Destination Located in Ganapathi Puram, A Locality in Nagercoil of Kanyakumari District. Lemur Beach Is a Secluded Beach Located in The Kanyakumari District of Tamil Nadu, India. The Beach Is Known for Its Pristine Blue Waters, Soft White Sand, And Breathtaking Natural Scenery. Lemur Beach Is Located in The Village of Muttom, Which Is About 32 Km from Kanyakumari Town. The Beach is Accessible by Road, and Visitors Can Hire a Taxi or Take a Bus from Kanyakumari Town to Muttom Village. The Nearest Airport and Railway Station Are in Trivandrum, which is about 85 Km Away. The beach is Surrounded by Lush Green Forests and Rocky Cliffs, Providing A Stunning Backdrop for The Blue Waters of The Arabian Sea. Visitors Can Enjoy a Peaceful Walk Along the Beach, Taking in The Natural Beauty of The Area.

Little Maldives

There Are Not Only Hotels Floating in The Middle of The Water, But the Low Tide, The Beautiful Sea Mixed With Blue And Green Colours, and The Coconut Trees that Make

You Look Up, Make Lemoore Beach Look Like The Original Maldives. It Is Situated at a Distance of 32 Km from Kanyakumari and About 14 Km from Nagercoil. This Beautiful Lemur Beach is Located in Kanapathipuram area next to Rajakamangalam area on the Road from Nagercoil to Kulaichal. On The Way There You Will Be Greeted by Coconut Trees on Both Sides. 5 Am To 8 Am Is Allowed from Monday to Saturday. Open 24 Hours on Sundays. There Are No Hostels There So It Is Better to Make Alternative Arrangements.

Specialty

This is one of the beaches where the water from Pachiparai Dam irrigates many fields and mixes with the Arabian Sea. It is one of the popular beaches for film shooting. Lemur Beach is the longest and widest beach in Kanyakumari district. Sitting here on the beach and enjoying the waves, you can feel the ecstasy inside you. This place is perfect for those who seek peace of mind, new places and spend time with family. This beach also has another name as Thousand Feet Pozhimugam. It is better to go here by own vehicle. People traveling by bus should go till Kanapathipuram and take an auto from there.

Don'ts: Don't pollute the beautiful beach. It is best to avoid walking into the sea as bathing is not allowed.

Note: Alcohol is not allowed here.

Tourism Development Through the Lemur Beach in Kanyakumari District

Tourism is one of the fastest growing industries across the world. In the rapidly changing global economic scenario, tourism is considered to be one of the largest and fast-growing industries. The occupation of tourism is providing very useful and fruitful avenues especially to those people who are engaged in tourism activities because through this smokeless industry, they are not only enhancing their standard of living but also generating income and employment opportunities. In the contemporary era of globalization and industrialization, the whole world has shrunk into a global village. The tourism has played a very decisive role to transform the world into a globalized economy where all nations can exchange free trade and culture and share their interest of mutual benefits based on tourism industry. India is one of the major destinations of the foreign tourists particularly the state of Tamil Nadu which has a rich cultural heritage among the Indian states. All over the world, the tourists are visiting it due to its climatic, scenic beauty and ecological resources.

Tourists may often move in formal and informal groups. There are different types of group tourists. There are exclusive groups like married couples, particularly honeymooners, family groups, friends-circles or groups of students studying in the same class. Recently cooperative holidays are enjoyed also by a group of workers belonging to a common business

establishment. Secondly people may form their group in the course of the journey itself. For instance, pilgrims may start their journey separately but the different terrain and the strain of the journey may often bring them together. Tourist are always on the lookout for hidden gems and want to explore something new. There are many unexplored places in India that we do not know. Today I will take you on a virtual tour of some of the hidden tourist place in lemur beach at Ganapathi Puram. It is the beautiful village. Anytime we go to lemur beach.

Motives for Tourism

Tourism is a complex and multifaceted phenomenon influenced by a variety of motives. People travel for different reasons, and their motives for tourism can be categorized in various ways. Here are some common motives for tourism:

Leisure and Recreation: Many people travel for relaxation, to escape from the routine of daily life, and to enjoy recreational activities such as sightseeing, shopping, and entertainment.

Cultural Exploration: Tourists often seek to explore and experience different cultures, traditions, and lifestyles. They may visit museums, historical sites, attend cultural events, and engage with local customs.

Nature and Adventure: Some travelers are drawn to natural attractions and outdoor activities. They seek adventure through activities such as hiking, trekking, wildlife safaris, and water sports in scenic landscapes.

Health and Wellness: Wellness tourism is on the rise, with people traveling to destinations that offer spa treatments, yoga retreats, meditation, and other health-focused activities to rejuvenate their mind and body.

Business and Conferences: Business and professional reasons drive many people to travel. Attending conferences, meetings, and business events are common motives for corporate travel.

Family and Social Visits: Visiting friends and relatives (VFR) is a significant motive for travel. People travel to spend time with family and friends, attend celebrations, or reconnect with loved ones.

Education and Learning: Travel for educational purposes includes activities such as attending workshops, language courses, or visiting educational institutions and museums to enhance one's knowledge and skills.

Religious Pilgrimages: Many people undertake journeys to religious sites for pilgrimage and spiritual fulfillment. These trips are often motivated by a desire for personal growth and religious experiences.

Special Events and Festivals: Travelers may plan trips to attend special events, festivals, concerts, or sports events happening in different parts of the world.

Shopping: Some individuals travel specifically for shopping, seeking unique products, souvenirs, or taking advantage of favorable economic conditions in certain destinations.

Volunteerism and Community Service: Voluntourism involves traveling with the primary purpose of contributing to the well-being of communities through volunteer work and community service projects.

Escape and Adventure: Some people travel to seek excitement, challenge, and a break from their regular lives. This could involve activities such as extreme sports, bungee jumping, or exploring remote and off-the-beaten-path destinations.

Understanding these various motives for tourism helps destinations and the tourism industry tailor their offerings to meet the diverse needs and interests of travelers. Additionally, individual travelers may have a combination of these motives when planning their trips.

Transport

The transport corporation was formed in 1.1.1974 from erstwhile Tamil Nadu state transport department with its headquarters at Nagercoil in Kanyakumari district and then named as Kattabomman transport corporation limited. This corporation was bifurcated on 1.4.1983 and Nesamony transport corporation was born with effect from 6.1.2004 this corporation and is functioning as its Nagercoil Region. Again, Madurai division was bifurcated and the Nagercoil region is headed by Tirunelveli division with effect from 1.11.2010.

The operational area of this region is very limited compared to other regions since the operational borders are approximately at 30kms radius and this district is surrounded by sea on three sides and one portion is covered by sea and one portion is covered by hills and in the western border with Kerala state. The Tamil Nadu state transport corporation Ltd., Nagercoil region is functioning with 12 Despots having Kanyakumari District as boundaries.

Coastal Tourism Circuit

Coastal Circuit will strengthen India's reputation as the "Sun, Sea, and Surf" land. India's littoral is comprised of Gujarat, Maharashtra, Goa, Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, and West Bengal, among other states. The lemur beach coastal tourism was hand over by the Scheme of "Darshan Swadesh". This scheme was used only for cost place tourist in reservations. During the coastal tourism circuit project cost reservation as Rs. 184 lakhs from the lemur beach. The coastal of lemur beach work was

started the date of commencement 27.03.2018 and end of the date of completion 28.02.2019. It was one only for a 100% funded by ministry of Tourism. They were reservation for the Components of Land Scaping, E-Toilet, Drinking water, Signage system.

The Swadesh Darshan Scheme, a Central Sector initiative, has been introduced by the Ministry of tourist of the Government of India for the integrated development of theme-based tourist circuits. The initiative aims to develop, broaden, and maximize the potential of India's tourism sector. The Swadesh Darshan Scheme, 15 circuit themes were including. This scheme was very useful to for a tourist development. It helpful for a more tourists were coming to visit. This is the development of the sources. Tourist Circuit is defined as a route having at least three major tourist destinations which are distinct and apart.

Kanyakumari Ganapathi Puram Centre for Sustainable Aquaculture

Kanyakumari Ganapathi Puram Centre for Sustainable Aquaculture, Tamil Nadu Fisheries University is located in currently we do not have any reviews or rating for Kanyakumari Ganapathi Puram Centre for Sustainable Aquaculture, Tamil Nadu Fisheries University. There are at least University departments in, out of which this University department has an overall rank of 26. Kanyakumari Ganapathi Puram Centre for Sustainable Aquaculture, Tamil Nadu Fisheries University has Address of the University department is Ayiramkal Pozhimugam, post, Ganapathi Puram, Tamil Nadu. During the Aquaculture we are visit and gave to interview their person and mostly growth in the pure water as shrimp. During the Aquaculture were more investment as it. There was including for a lab, managing room and etc. It was the one of the revenues of the government.

Lemur Beach - Tourist Destination in Kanyakumari

Kanniyakumari's Lemur Beach has been crowned the "Best Beach and Coastal Destination" at India Today Tourism Survey & Awards 2023. Lemur Beach also known as Ganapathi Puram beach, located in Kanniyakumari, is one of the most popular tourist destinations in southern India. Known for its pristine beaches and breathtaking views, this beach offers visitors a chance to relax and unwind while enjoying the natural beauty of the area. The beach is named after the lemurs, small primates that are native to Madagascar, but are not found in this part of India. The name, however, does not detract from the beauty of the beach, which is surrounded by lush greenery and clear blue waters. The beach is clean and well-maintained, with plenty of space for visitors to spread out and enjoy the scenery. One of the main attractions of Lemur Beach is the stunning sunrise and sunset views. Visitors can enjoy the early morning sunrise and watch as the sun slowly rises over the horizon,

casting a warm glow over the beach. In the evening, visitors can watch as the sun sets into the ocean, painting the sky with a brilliant array of colours.

The beach is also known for its water sports activities, including swimming, boating, and fishing. For those looking to relax, there are plenty of shaded areas along the beach where visitors can sit and enjoy the cool ocean breeze. The beach is also home to several small cafes and restaurants, where visitors can sample local cuisine and enjoy a refreshing drink while taking in the stunning views. In addition to the beach, the area surrounding Lemur Beach is home to several other attractions, including the Vivekananda Rock Memorial and the Thiruvalluvar Statue, both of which are located just a short distance from the beach. These iconic landmarks offer visitors a chance to learn about the history and culture of the area, and are a must-visit for anyone traveling to Kanyakumari.

Overall, Lemur Beach is a must-visit destination for anyone traveling to Kanyakumari. With its stunning natural beauty, array of water sports activities, and nearby attractions, there is something for everyone at this beautiful beach. Whether you are looking to relax and unwind, or to explore the surrounding area, Lemur Beach is the perfect place to do it.

Tourism in Lemur Beach

"The world is a country which nobody ever yet knew by description; one must travel through it one's self to be acquainted with it"

Once said by the Philip Dormer Stanhope, 4th Earl of Chesterfield, a British statesman and man of letters. As the saying goes, Kanyakumari is a dream destination that as to be explored to its fullest.

Lemur Beach in Kanyakumari is basically a soulful paradise, beach lover's preferred selection and most importantly a sanctified spiritual address of Hindus. Kanyakumari district is very unique and so surprisingly impressive. Kanyakumari is illustrious for its radically distinctive geographic features on two exclusive grounds:

- Kanyakumari marks the land's ending point of the Republic of India
- Meeting point of three great seas, Indian Ocean, Arabian Sea and Bay of Bengal

Located almost 700 km away from the busy metropolis of Chennai, Kanyakumari is one of its kind destinations that attract visitors from all over the world. The district of Kanyakumari unveils a whole new world that is filled with nature and tranquillity all around. Kanyakumari is long familiar for its never-ending list of tourist attractions that cater to the

needs and demands of the visitors in terms of tourism. Be it temples or other religious sites, beaches or nature spots, boating or other fun activities, the wide range of tourist attractions the district has to extend is simply astonishing. Specially Lemur beach is long familiar for its one of the tourist attractions that cater to the needs and demands of the visitors in terms of tourism.

Kanyakumari is regarded as one of the most tourist-friendly districts in the southern state of Tamil Nadu. The district is literally situated at the south most point of South India, which itself is a singular thing to look for! Kanyakumari was once called as Cape Comorin during the British time and is now fondly called as Kumari Mona in the local language of Tamil. The name Kanyakumari is derived from the Goddess Kumari Amman dedicated to Virgin Goddess Kanyakumari and the Kumari Amman Temple is located on the land along the edge of the meeting of the Arabian Sea, Indian Ocean and Bay of Bengal. likewise, Amman temple and other temples, Churches and Mosque also attracted by tourist there at near Lemur Beach.

Religious Sites in Ganapathi Puram

The religious sites of Ganapathi Puram are celebrated all over the globe for their wonderful architecture. Besides, the Tamil people are known for their devotedness towards their respective religious beliefs and religious sites. The major population of the southern state of Tamil Nadu being followers of Hinduism, the entire of Ganapathi Puram is scattered with temples.

Temples at lemur beach

The lemur beach overlooking the gently lapping waves of blue sea this is one of the most gorgeous temples at lemur beach and is renowned for its mystical aura and intriguing history. A temple a religious building that's meant for worshipping or praying Hindu temples are typical devoted to one specific god. Arulmigu Dharma Sastha Temple is considered a scared shrine entirely dedicated to Iyappan. View the beautiful temple that depicts better architectural significance along with a very major highlight add that is four musical pillars created out of single stone that makes it more magnificent. Next ArulmiguVandimalachi Amman Temple Thirukovil as popularly known as Devi Amman, and the majestic architecture of the temple gets shaped by Pandya's and gets repowered by Marthandawarma. Experiencing tragic faith along with passionate love for Goddess Vandimalachi Amman.

Kurusady at lemur beach

A Church is one of the groups of people within the Christian religion, for example Catholics or Methodists, that have their own beliefs, clergy, and forms of worship. Inside a

church, a service given by a religious official that helps guide worship. Church can also refer to the group of people you see regularly at Sunday's service. "Church." Matha Kurusady is situated at Lemur Beach in Ganapathi Puram. *Matha Church is also attracted tourists due to their peaceful and calm appeal.*

Secluded beach

Lemur Beach is a secluded beach located in the Kanyakumari district of Tamil Nadu, India. The beach is known for its pristine blue waters, soft white sand, and breathtaking natural scenery.

Name meaning of Lemur Beach

The beach is named after the endangered primate species, the Lemur, which is found in the nearby forest areas.

Location and Accessibility

Lemur Beach is located in the village of Muttom, which is about 32 km from Kanyakumari town.

Way to reach the Lemur Beach

The beach is accessible by road, and visitors can hire a taxi or take a bus from Kanyakumari town to Muttom village. The nearest airport and railway station are in Trivandrum, which is about 85 km away.

Natural Scenery

The beach is surrounded by lush green forests and rocky cliffs, providing a stunning backdrop for the blue waters of the Arabian sea. Visitors can enjoy a peaceful walk along the beach, taking in the natural beauty of the area.

Water Sports and Activities

Apart from water sports, visitors can take a stroll along the beach, relax in the shade of the palm trees, or simply enjoy the stunning natural scenery of the area.

Restrictions on water sports at the beach

Visitors are required to follow safety guidelines and restrictions set by the local authorities.

Best time to visit the Lemur Beach

The best time to visit the beach is between October and March when the weather is pleasant and ideal for water sports.

Necessary to book accommodation in advance

It is recommended to book accommodation in advance, especially during peak tourist season, to avoid any last-minute inconvenience.

Accommodation and Dining

There are a few hotels and guesthouses located in Muttom village, offering comfortable accommodation for visitors.

Kinds of food at near the beach

Visitors can enjoy a range of local delicacies at the small restaurants and food stalls located near the beach. Seafood lovers can indulge in fresh catch of the day, prepared in a variety of local styles.

Tamil Nadu Government Accommodation

Hotel Tamil Nadu, operated by Tamil Nadu Tourism Development Corporation (TTDC) provides visitors with a wide range of facilities which include spacious rooms with or without AC, multicuisine restaurant, conference halls, parking space, and indoor games and so on. Kanyakumari also offer a lot of private accommodation options too.

Conclusion

Lemur Beach also known as Ganapathi Puram beach, located in Kanniyakumari, is one of the most popular tourist destinations in southern India. Known for its pristine beaches and breathtaking views, this beach offers visitors a chance to relax and unwind while enjoying the natural beauty of the area. The beach is named after the lemurs, small primates that are native to Madagascar, but are not found in this part of India. The name, however, does not detract from the beauty of the beach, which is surrounded by lush greenery and clear blue waters. The beach is clean and well-maintained, with plenty of space for visitors to spread out and enjoy the scenery. One of the main attractions of Lemur Beach is the stunning sunrise and sunset views. Visitors can enjoy the early morning sunrise and watch as the sun slowly rises over the horizon, casting a warm glow over the beach. In the evening, visitors can watch as the sun sets into the ocean, painting the sky with a brilliant array of colours. The beach is also known for its water sports activities, including swimming, boating, and fishing. For those looking to relax, there are plenty of shaded areas along the beach where visitors can sit and enjoy the cool ocean breeze. The beach is also home to several small cafes and restaurants, where visitors can sample local cuisine and enjoy a refreshing drink while taking in the stunning views. In addition to the beach, the area surrounding Lemur Beach is home to several other attractions, including the Vivekananda Rock Memorial and the Thiruvalluvar Statue, both of which are located just a short distance from the beach. These iconic landmarks offer visitors a chance to learn about the history and culture of the area,

and are a must-visit for anyone traveling to Kanyakumari. Overall, Lemur Beach is a must-visit destination for anyone traveling to Kanniyakumari. With its stunning natural beauty, array of water sports activities, and nearby attractions, there is something for everyone at this beautiful beach. Whether you are looking to relax and unwind, or to explore the surrounding area, Lemur Beach is the perfect place to do it.

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A Study on Pradhan Mantri Awas Yojana Gramin In Kanyakumari District

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ABSTRACT

Pradhan Mantri Gramin AwasYojana, Previously Indira Awas yojana is a social welfare programme, created by the Indian Government to provide housing for the rural poor in India. In the year 2015, the Indian government introduced the Pradhan Mantri Awas Yojana (PMAY) to provide affordable housing to all citizens by 2022. PMAY-Housing for All (Gramin) is drawing attention of the researchers in evaluating the programme. The present research has been focused on studying of the PMAY scheme in Kanyakumari District. The study analyses the work completion and landless beneficiaries under Pradhan Mantri Awas Yojana Gramin in Kanyakumari District from the year 2016 -17 to 2023 – 2024. It also provides information on the problems faced by the beneficiaries in the study area. The study makes use of both primary and secondary data. The data on Pradhan Mantri Awas Yojana Gramin has been collected from the website of PMAYG-Report. The primary data were collected from 25 sample respondents by using convenient sampling method. The collected data have been properly processed with the help of transcription. To make present research study highly effective, the statistical techniques such as percentages and averages have been used. The major problems faced by the beneficiaries are delay in sanction, lack of capital and lack of electricity supply. The majority of the sample respondents mentioned that the delay in response is the major problem faced by them.

Keywords: *Housing, PMGAY, Rural development*

Introduction

Pradhan Mantri Gramin AwasYojana, Previously Indira Awas yojana is a social welfare programme, created by the Indian Government to provide housing for the rural poor in India. Indira Awas yojana was launched in 1985 as one of the major flagship programs of the Ministry of Rural Development to construct houses for the below poverty line population in the villages. It was restructured in the year 2015. In the year 2015, the Indian government introduced the Pradhan Mantri Awas Yojana (PMAY) to provide affordable housing to all citizens by 2022. The scheme was launched to aid the middle-income community, economically weaker sections (EWS) and low-income groups (LIG). The scheme in urban areas called as Pradhan Mantri Awas Yojana-Urban (PMAY-U) and in rural areas called as Pradhan Mantri Awas Yojana Gramin (Pradhan Mantri Awas Yojana Rural)

Statement of the Problem

Even though there are lot of housing programmes implemented in India since independence, these programs lacked continuity and interconnectedness, which has drawn attention of the earlier researches to assess housing policies and programmes in India. Recently launched affordable housing scheme, PMAY-Housing for All (Gramin) is drawing attention of the researchers in evaluating the programme. The present research has been focused on studying of the PMAY scheme in Kanyakumari District.

Objectives

- ✓ To study the Pradhan Mantri Awas Yojana Gramin in Kanyakumari District
- ✓ To analyses the work completion under Pradhan Mantri Awas Yojana Gramin in Kanyakumari District
- ✓ To identify the landless beneficiaries in Kanyakumari District
- ✓ To understand the problems faced by the beneficiaries in the study area

Significance of the Study

- ✓ By this study one can understand the progress of PMAYG in Kanyakumari District
- ✓ We can identify which block dominates in PMAYG in Kanyakumari District
- ✓ From this study, one can understand landless beneficiaries of the block wise PMAYG in Kanyakumari District

Methodology

The study made use of both primary and secondary data. The secondary data were collected from the website of Indian Brand Equity Foundation and website of PMAYG-Report. The study also uses the primary data to understand the problems faced by the beneficiaries. The data were collected from 25 sample respondents by using convenient sampling method.

Tools of Analysis

The data obtained from the various websites from the year 2016 - 2023 (till September) are carefully tabulated and analysed. The collected data have been properly processed with the help of transcription. To make present research study highly effective, the statistical techniques such as percentages, and averages have been used. A number of tables related to Agastheeswaram, Rajakkamangalam, Thiruvattar, Thuckalay, Thoivalai, Melpuram, Munchirai, Killiyoor, and Kurunthencode block have been prepared from the collected data.

Research Period

As the present study was carried out by using the secondary data the period of study is 2016 - 2017 to 2023 - 2024 (till September). The primary data were collected during the month of July to October, 2023.

Analysis of Pradhan Mantri Awas Yojana in Kanyakumari District

The collected data from various sources are analysed to understand the effective working of Pradhan Mantri Awas Yojana Gramin in Kanyakumari District. They are given below.

Houses sanctioned during the year 2016 - 2024 in Kanyakumari District

The table 1 shows the number of houses sanctioned in Kanyakumari District from the year 2016 - 2023 (till September). The total no of houses sanctioned is 2,356. From the table it is clear that the number of houses sanctioned is low during the year 2023 - 2024. The number of houses sanctioned is 37 during the period. The highest number of houses sanctioned is 849 during the period 2017 - 2018.

Table 1. Number of Houses sanctioned during the year 2016 - 2024 in Kanyakumari District

Year	No. of Houses sanctioned	Percentage
2016 - 17	117	4.96
2017 - 18	849	36.03
2018 - 19	275	11.67
2019 - 20	128	5.43
2020 - 21	154	6.53
2021 - 22	653	27.71
2022 - 23	143	6.06
2023 - 24 (till September)	37	1.57
Total	2,356	100

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Block-wise houses sanctioned in Kanyakumari District

The Table 2 shows the block wise no. of houses sanctioned in Kanyakumari District. The total number of houses sanctioned is 2, 343. From the table it is clear that the number of

houses sanctioned is low in Killiyoor block which is 150. The highest number of houses sanctioned is in Melpuram block and the houses sanctioned are 435.

Table 2. Block wise houses sanctioned in Kanyakumari District during the period 2016 - 2024

Block Name	Total no. of houses sanctioned	Percentage
Agastheeswaram	185	7.89
Killiyoor	150	6.40
Kurunthencode	227	9.68
Melpuram	435	18.56
Munchirai	271	11.56
Rajakkamangalam	297	12.67
Thiruvattar	268	11.43
Thovalai	325	13.87
Thuckalay	185	7.89
Total/Avg	2,343 (260.33)	100

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Houses completed in Kanyakumari District

The Table 3 shows the number of houses completed in each block in Kanyakumari District. The total number of houses completed is 2,194. From the table it is clear that the number of houses completed is low in Killiyoor block and the houses completed is 148. The highest no. of houses completed is in Melpuram block and the houses completed are 424.

Impact of seasonality on completed house.

The Table- 3 shows the impact of seasonality on completed house. From the Table it is clear that the average completion rate in summer, rainy, winter and spring are 178, 202, 171 and 163 respectively. The highest average completion rate is in rainy season and the lowest is in spring season.

Table 3. Block wise impact of seasonality on completed house

Block Name	Average completion rate in Summer (in days)	Average completion rate in Rainy (in days)	Average completion rate in Winter (in days)	Average completion rate in Spring (in days)
Agastheeswaram	224	243	143	265
Killiyoor	177	168	128	140
Kurunthencode	220	210	174	194

Melpuram	164	184	167	152
Munchirai	202	187	185	162
Rajakkamangalam	149	204	158	155
Thiruvattar	147	208	174	130
Thovalai	163	226	221	158
Thuckalay	162	189	143	136
Total/Avg	178 (19.77)	202 (22.44)	171 (19)	163 (18)

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Payment rejected status

The Table-4 shows the payment rejected status. From the Table 4, it is clear that the total no. of payment rejected is 202, the total no. of payment after rejection is 197 and the total no. of payment not initiated after rejection is 5.

Table 4. Block wise payment rejected status

Block Name	Rejected	Payment after rejection	Payment not initiated after rejection
Agastheeswaram	13	13	0
Killiyoor	5	5	0
Kurunthencode	25	24	1
Melpuram	53	52	1
Munchirai	4	4	0
Rajakkamangalam	40	39	1
Thiruvattar	19	18	1
Thovalai	21	20	1
Thuckalay	22	22	0
Total	202 (22.44)	197 (21.88)	5 (0.55)

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Delay in fund transferred

The Table- 5 shows the delay in fund transferred. From the Table 5 it is understood that the highest days for the delay in fund transferred in 0-5 days which amount the total of 5509 and the lowest days for the delay in fund transferred in above 30 days is 158.

Table 5. Block wise delay in fund transferred

Block Name	0-5 Days	6-10 Days	11-15 Days	16-20 Days	20-30 Days	>30 Days
Agastheeswaram	483	173	46	10	9	19
Killiyoor	296	231	25	21	12	12
Kurunthencode	530	191	57	23	27	10
Melpuram	1095	393	127	62	18	26
Munchirai	634	295	55	46	36	21
Rajakkamangalam	761	208	70	37	14	10
Thiruvattar	612	270	91	20	27	28
Thovalai	715	341	62	11	12	13
Thuckalay	383	209	57	17	16	19
Total	5509	2311	590	247	171	158

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Awaassoft Remand Progress Report

The Table- 6 shows the Awaassoft Remand Progress Report. From the Table 6 it is found that the minority category has the highest rate which is 3313 and the lowest category goes to ST which is 32.

Table 6. Block wise Awaassoft Remand Progress Report

Block Name	ST	SC	Minority	Others	Total
Agastheeswaram	3	47	28	178	256
Killiyoor	0	14	171	99	284
Kurunthencode	0	28	193	358	579
Melpuram	4	20	314	217	555
Munchirai	0	39	278	767	1084
Rajakkamangalam	0	87	78	626	191
Thiruvattar	3	19	770	241	1033
Thovalai	22	110	158	388	678
Thuckalay	0	44	410	439	893
Total	32	408	2400	3313	6153

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Age Wise Sanctioned

The Table- 7 shows the Age wise sanction. From the Table 7 it is realised that the highest age wise sanction in 18-71 years is 2022, the lowest age wise sanctioned is 0-10 and above 100 is 1.

Table 7. Block wise age wise sanctioned

Block Name	0-10	11-17	18-71	71-80	81-90	91-100	Above 100
Agastheeswaram	0	0	155	22	7	1	0
Killiyoor	0	0	122	21	5	2	0
Kurunthencode	0	0	205	17	4	1	0
Melpuram	0	0	381	42	10	2	0
Munchirai	0	0	222	36	10	2	1
Rajakkamangalam	1	0	265	25	4	2	0
Thiruvattar	0	1	228	30	7	2	0
Thovalai	0	1	292	21	9	2	0
Thuckalay	0	0	152	23	6	0	0
Total	1	2	2022	237	62	14	1

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Landless Beneficiaries Report

The Table - 8 shows the landless beneficiaries. From the Table 8 it is clear that the total landless beneficiaries are 1483, total landless who got sanctioned is 51 and total landless who are not sanctioned is 1432. The highest landless beneficiaries are in Thovalai Block.

Table 8. Block wise landless beneficiaries report

Block Name	Total Landless	Total Landless who got Sanctioned	Total Landless who are not Sanctioned
Agastheeswaram	269	4	265
Killiyoor	7	2	5
Kurunthencode	240	15	225
Melpuram	62	1	61
Munchirai	25	1	24
Rajakkamangalam	276	5	271
Thiruvattar	18	1	17
Thovalai	500	20	480
Thuckalay	86	2	84
Total	1483	51	1432

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Houses Progress against the Target Financial Year

The Table 9 shows that Houses Progress Against the Target Financial Year. From the table 9, it is found that the Target fixed by District is 2390, registered houses are 2553 and completed houses are 2206.

Table 9. Block wise houses progress against the target financial year

Block Name	Target fixed by District	Registered	Completed
Agastheeswaram	190	231	183
Killiyoor	152	157	148
Kurunthencode	227	257	206
Melpuram	441	448	429
Munchirai	276	280	270
Rajakkamangalam	303	318	265
Thiruvattar	274	283	257
Thovalai	335	389	275
Thuckalay	192	190	173
Total	2390	2553	2206

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Average Completion Time of Houses Sanctioned

The Table 10 shows that the Average Completion Time of Houses Sanctioned. It is found that the highest number of houses completed is in 10 months and the total number of houses completed in 10 months is 2005.

Table 10. Block wise average completion time of houses sanctioned

Block Name	Average Completion Time in Days	No. of house completed within 10 months	No. of house completed within 365 days
Agastheeswaram	241	145	13
Killiyoor	158	144	3
Kurunthencode	206	181	10
Melpuram	168	395	18
Munchirai	184	249	12
Rajakkamangalam	171	248	4
Thiruvattar	177	243	5
Thovalai	195	236	12
Thuckalay	167	164	2
Total	184	2005	79

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Unfreeze the Account of Beneficiary list

The Table 11 shows that unfreeze the Account of Beneficiary list. From this table 11, it is understood that the highest one-time change is in Munchirai Block which is 6 and the lowest in Kurunthencode and Thiruvattar Block. These blocks have one time change.

Table 11. Block wise unfreeze the account of beneficiary list

Block Name	One Time Change	Account Rejected
Agastheeswaram	4	26
Killiyoor	3	26
Kurunthencode	1	5
Melpuram	2	21
Munchirai	6	9
Rajakkamangalam	5	19
Thiruvattar	1	13
Thovalai	2	21
Thuckalay	2	14
Total	26	154

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

House Completed but Amount Not Released Fully

The Table 12 shows that the House Completed but Amount Not Released Fully. The table 12 clearly shows that the total amount not completed is 4, the total amount sanctioned is 4.800, the total amount released is 2.910, and the total amount pending is 1.890.

Table 12. Block wise Completion house but amount not released fully

Block Name	Amount Not Completed	Amount Sanctioned	Amount Release	Amount Pending
Agastheeswaram	0	0	0	0
Killiyoor	2	2.400	1.322	1.078
Kurunthencode	1	1.200	0.794	0.406
Melpuram	0	0	0	0
Munchirai	0	0	0	0
Rajakkamangalam	0	0	0	0
Thiruvattar	0	0	0	0
Thovalai	1	0	0	0
Thuckalay	0	1.200	0.794	0.406
Total	4	4.800	2.910	1.890

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Administrative and Transaction Delay

The Table 13 shows that the Administrative and Transaction Delay. From the table 13 one can understand that the total average construction time is 116, the total average

administrative time is 70, the total average financial transaction time is 9 and the total actual average completion time is 79.

Table13. Block wise administration and transaction delay

Block Name	Average Construction Time (in days)	Average Administrative Time (in days)	Average Financial Transaction Time (in days)	Actual Average Completion Time
Agastheeswaram	167	82	8	90
Killiyoor	110	49	9	58
Kurunthencode	100	114	11	125
Melpuram	113	56	9	65
Munchirai	116	68	9	77
Rajakkamangalam	84	88	8	96
Thiruvattar	118	62	8	70
Thovalai	134	64	9	73
Thuckalay	115	53	9	62
Total	116	70	9	79

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

No. of Houses where BDO Approved the Name Mismatch till 2020 - 2021

The Table 14 shows that the No. of Houses Where BDO Approved the Name Mismatch Till 2020-2021. The table 14 shows that the total mismatched is 814, the total not matched is 261 and the total mismatched is 126.

Table 14. Block wise number of houses where BDO approved the name mismatch till 2020 - 2021

Block Name	Total mismatched	Not matched	Mismatched
Agastheeswaram	71	20	11
Killiyoor	58	20	5
Kurunthencode	88	15	22
Melpuram	104	42	4
Munchirai	116	41	17
Rajakkamangalam	90	31	10
Thiruvattar	127	37	32
Thovalai	62	11	15
Thuckalay	98	44	10
Total	814	261	126

Source: Rhreporting.nic.in/netiay/dataanalytics/AverageCompletionTimeADReport.aspx

Problems faced by Beneficiaries.

The Table 15 shows the problems faced by the beneficiaries. The major problems faced by them are delay in sanction, lack of capital and lack of electricity supply. The majority of the sample respondents (36%) mentioned that the delay in response is the major problem faced by them.

Table15. Problems faced by beneficiaries

Sl. No	Problems	No. of respondents	Percentage
1	Delay in Fund Transfer	6	24
2	Delay in Response	9	36
3	Delay in sanction	2	8
4	Lack of Capital	4	16
5	Lack of Electricity Supply	4	16
-	Total	25	100

Source: Primary Data

Findings, Suggestions and Conclusion of the Study

The important findings based on the analysis are listed below:

Findings

- ❖ The no. of house sanctioned is low in Killiyoor block and the houses sanctioned are 150. The highest no. of houses sanctioned is in Melpuram block and the houses sanctioned are 435.
- ❖ The no. of house completed is low in Killiyoor block and the houses completed are 148. The highest no. of houses completed is in Melpuram block and the houses completed are 424.
- ❖ The highest average completion rate is in rainy season and the lowest is in spring season. It shows the impact of seasonality in completion of the houses.
- ❖ The total beneficiary's name changed due to death case marked is 18 and the total death case approved is 15.
- ❖ The total no. of payment rejected is 202, the total no. of payment after rejection is 197 and the total no. of payment not initiated after rejection is 5.
- ❖ The highest days for the delay in fund transferred in 0-5 days is 5509 and the lowest days for the delay in fund transferred in above 30 days is 158.

- ❖ The Awaassoft Remand Progress Report shows that the minority category has the highest rate which is 3313 and the lowest category goes to ST which is 32
- ❖ The highest age wise sanction in 18-71 ages is 2022, the lowest age wise sanctioned is 0-10 and above 100 is 1.
- ❖ The total landless beneficiaries are 1483, total landless who got sanctioned is 51 and total landless that are not sanctioned is 1432.
- ❖ The Target fixed by District is 2390, registered houses are 2553 and Completed houses are 2206.
- ❖ The highest no. of houses completed is in 10 months and the total no. of houses completed in 10 months is 2005.
- ❖ The highest one time change in Munchirai Block is 6 and the lowest in Kurunthencode and Thiruvattar Block is 1 respectively.
- ❖ The total no. of accounts rejected by PFMS is 14.
- ❖ The total amount not completed is 4, the total amount sanctioned is 4.800, the total amount released is 2.910, and the total amount pending is 1.890. The completion of houses was possible but the amounts were not completed fully.
- ❖ The total average construction time is 116, the total average administrative time is 70, the total average financial transaction time is 9 and the total actual average completion time is 79.
- ❖ The total mismatched name is 814, the total not matched is 261 and the total mismatched is 126. The BDO approved the name mismatch till 2020-2021.
- ❖ The major problems faced by the beneficiaries are delay in sanction, lack of capital and lack of electricity supply. The majority of the sample respondents (36%) mentioned that the delay in response is the major problem faced by them.

Suggestions

- Periodical visit by the government officials in rural place to explain uneducated people how to take the loan in any central Government scheme.
- Proper awareness should be given to the people about this scheme.
- Social groups can be formulated for the rural poor to apply this scheme through online.
- The Government should take some effective steps to improve the application process.
- The need of the hour is to conduct an all-India housing survey to assess the present housing shortage of rural people, especially for downtrodden in rural areas.

- To improve the environment of human settlements, Government should provide drinking water, Sanitation and other basic amenities.
- The priority must be accorded to victims of natural calamities, low-income groups, economically and socially weaker sections, widows, and matriarchal family.

Conclusion

The present study showed that the major problems faced by the beneficiaries are delay in sanction, lack of capital and lack of electricity supply. The majority of the sample respondents mentioned that the delay in response is the major problem faced by them. Despite of these problems faced by the beneficiaries; the scheme provided housing for the rural areas. After the implementation of this scheme many rural areas in Tamil Nadu have developed well economically. There are significant changes about housing development in rural areas through the proper implementation of Pradhan Mantri Awas Yojana.

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Central Bank Digital Currency and its Implications for the Monetary System

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ABSTRACT

This study explores the transition from tangible to digital currency, focusing on the rise of Central Bank Digital Currency (CBDC). It covers CBDC's concept, features and global implementation stages with 95% of global GDP represented by 114 countries exploring CBDC its significance in financial inclusion and stability is emphasized. Notable CBDC initiatives in China, Sweden, and Brazil are highlighted. In India, the pilot stage of the retail CBDC is a significant step towards enhancing payment efficiency and promoting financial inclusion.

Keywords: Digital currency, Monetary system, Monetary policy.

Introduction

Currency has travelled a long way in the course of history from barter system to metallic coins to paper currency and finally to electronic form, a transition from tangible to intangible form of money. This concept of intangible or digital currency is gaining much momentum in the 21st century financial system.

Digital currency (digital money, electronic money or electronic currency) is any currency, money or money-like asset that is primarily managed, stored or exchanged on digital computer systems, especially over the internet. Digital currency may be recorded on a distributed database on the internet, a centralized electronic computer database owned by a company or bank, within digital files or even on a stored value card. Types of digital currencies include crypto currency, virtual currency and central bank digital currency.

A CBDC (Central Bank Digital Currency) is a legal tender issued by a Central bank in a digital form. In the Union Budget 2022, Finance Minister Nirmala Sitharaman had announced the launch of CBDC by the RBI starting 2022 - 2023 which according to the Hon.Minister, will give boost to the digital economy. "We see clear advantages in a central bank driven digital currency, because in this day and age, bulk payments happening between countries, large transactions between institutions and large transactions between central banks themselves of each country are all better enabled with digital currency." According to Atlantic Council, 114 countries representing over 95% of global GDP are currently exploring a CBDC

in contrast to May 2020, when only 35 countries were considering a CBDC. So far, 11 countries have launched their CBDCs while 18 countries including China and India are in the pilot stage. When the countries around the world are racing to launch their own digital currency, our study seeks to analyse the relevance of CBDCs in the contemporary world and how they will change the structure of the monetary system, especially in India.

Objectives of the Study

1. To explain the concept of Central Bank Digital Currency (CBDC)
2. To understand the policy implications of CBDC
3. To trace the global scenario regarding CBDC implementation
4. To analyse the significance of CBDC in India

Methodology

The study is based on secondary data. Main sources of data include international articles, journals, news reports, budget presentation, research presentations and internet. Concept note on Central Bank Digital Currency released by the Reserve Bank of India served as a major source of data collection. The websites of the central banks of the different countries were referred to for sourcing the data.

CBDC: The Concept

Central Bank Digital Currency (CBDC) is a digital form of currency notes issued by a central bank. While most central banks across the globe are exploring the issuance of CBDC, the key motivations for its issuance are specific to each country's unique requirements. A CBDC is a central bank liability, denominated in an existing unit of account, which serves both as a medium of exchange and as a store of value. Reserve Bank defines CBDC as the legal tender issued by a central bank in a digital form. It is the same as a sovereign currency and is exchangeable one-to-one at par (1:1) with the fiat currency. While money in digital form is predominant in India for example in bank accounts recorded as book entries on commercial bank ledgers a CBDC would differ from existing digital money available to the public because a CBDC would be a liability of the reserve bank and not of a commercial bank.

CBDC: Features

- CBDC is a sovereign currency issued by central banks in alignment with their monetary policy.
- It appears as a liability on the central bank's balance sheet.

- It must be accepted as a medium of payment, legal tender and a safe store of value by all citizens, enterprises and government agencies.
- It will be freely convertible against commercial bank money and cash.
- It is a fungible legal tender for which holders need not have a bank account.
- It is expected to lower the cost of issuance of money and transactions.

Design Aspects of CBDC Types

- Wholesale CBDC for faster interbank payments and secure settlement.
- Retail CBDC for individuals acting as digital cash issued by the central bank, potentially replacing physical currency.

CBDC Forms

- Account based CBDC with a trusted intermediary, suitable for wholesale CBDC
- Token-based CBDC, closer to physical cash, verifying ownership without an intermediary, preferred for Retail CBDC.

CBDC Issue and Management

- Direct Model: Central bank handles CBDC issuance and management.
- Indirect Model: Central bank issues CBDC through intermediaries, similar to current physical currency system.

CBDC Significance

1. Financial Inclusion: CBDCs offer direct access to financial services, especially for the unbanked stimulating participation in the digital economy.
2. Security and Reliability: CBDCs provide secure digital payment options, enhancing online and offline transactions and streamlining cross-border payments.
3. Guarding Financial Stability: CBDCs can mitigate risks and ensure stable payment alternatives across different platforms.
4. Towards a Less-Cash Society: CBDCs complement cash, aiding in reducing tax evasion, money laundering, and providing a more traceable form of payment. Overall, CBDCs serve as a secure, accessible and reliable digital currency option, aligning with the trend towards a less cash-dependent society.

CBDC Key Principles

1. Non-disruption: CBDC should not disrupt central bank operations or compromise financial stability. It must ensure uniformity and seamless interchangeability of currency forms.

2. Coexistence: CBDC should complement existing forms of currency, working in harmony with them to achieve public policy goals. It should be a tool for financial inclusion, particularly in unbanked areas.
3. Innovation and Competition: The CBDC ecosystem should promote continuous innovation and efficiency, encouraging healthy competition with other digital payment systems. Involvement of PSPs, public and commercial banks is vital for adoption and accessibility. Private economic agents should have the freedom to choose their preferred currency and payment system for transactions.

Policy Implications of CBDC

1. Monetary Policy: CBDC may enable more timely transmission of monetary policy. The extent of its impact will depend on usage and design. A larger balance sheet might be required if CBDC substitutes other forms of currency.
2. Liquidity Management: Increased CBDC demand may lead to deposit outflows from banks, potentially affecting reserve money, money supply and liabilities. It could also impact central bank balance sheets.
3. Legal Implications: Current central bank laws often don't permit CBDC issuance to the public. Classification as currency and legal status of token-based CBDCs remain unclear.
4. Financial Stability: CBDC can benefit financial resilience but may also disrupt existing financial structures. Safeguards like user access criteria and transaction limits are being explored.
5. Bank Balance Sheets: Substitution of assets and liabilities due to CBDC adoption may affect bank balance sheets, potentially leading to changes in central bank liabilities and assets. If commercial banks face liquidity constraints, it may necessitate additional central bank reserves issuance.

CBDC and its Implications: Global and Indian Perspectives

In the 17th Century, the Bank of England became the first bank to regularly issue banknotes as an alternative to coins, precious stones, etc. to function as a means of payment. As centuries passed, maintaining price stability became a primary concern for central banks around the world. In 21st Century the financial sector is buzzing with a new revolutionary concept which is a form of intangible money Central Bank Digital Currencies.

The latest reports projected that nearly 90% of the central banks around the world are exploring CBDCs. In the previous year, 40% of countries had entered the experimenting stage which has now risen to 60%. China is the major economy which is most advanced in its CBDC development. The People's Bank of China has been running its digital currency tests

since April 2020 with the help of four banks in the country. Thousands of customers have already been involved with the pilot stage; spending two billion Yuan in over four million transactions. For China, the idea of a central bank digital currency incorporates geopolitical considerations too, providing a mechanism to shift away from using the US Dollar because most of the real-world trade is denominated and invoiced in Dollars. China sees this as an obstacle for them to push the renminbi into the global financial system and global trading system. Having a digital currency would potentially be a significant step to overcome the same. But it is not only China; the European Central Bank had plans for a digital euro before a few years itself. It had explained that the digital currencies may help to remove the issues of money laundering, financing of terrorism, privacy of users and their information. It is looking at how a digital euro could be designed and distributed, as well as the impact it could have on the market and then decide whether to start the process of actually developing it.

But a lot of aspects regarding this system may depend upon how much people would use CBDC's and no central bank wants them to completely replace traditional cash but rather to complement it. There would be troubles when CBDCs replace bank deposits by a large amount because of shifting their savings from bank account to CBDC's. The banks could face the problem of liquidity crunch which could affect the financing of the whole economy.

As we move towards a cashless society CBDC's to emerge as a trusted and convenient currency will take significant time.

Tracking the Stages of CBDC Implementation

Several countries across the globe are exploring the concept of CBDC and hence are at various stages of its implementation, mainly research, development, pilot and launched stages. A global example of each stage is analysed below.

CBDC at launched stage-The Bahamas-Sand Dollar project

In 2020, the Bahamas launched the world's first central bank digital currency, the Sand Dollar. It's the digital version of the Bahamian dollar (B\$) issued by the Central Bank. It offers flexible access via mobile apps or payment cards, enhancing financial services. The Sand Dollar ensures monetary stability like the Bahamian fiat. Around 90% of Bahamians use mobile phones, making it easily accessible. This initiative aims for financial inclusion, especially for the 20% without bank accounts.

CBDC at pilot stage-Sweden's E-krona project

Sweden leads in CBDC progress. Riksbank, with Accenture, began building a CBDC platform in 2020. In 2021, e-krona's trial indicated viability. Phase two results in 2022 showed successful offline functionality and integration with banks. Riksbank, along with

other central banks, initiated Project Icebreaker in 2022 for cross-border CBDC payments, with a final report due in 2023.

CBDC at development stage-Brazil's Digital Real project

The Digital Real is Brazil's move towards modernizing its economy. Banco Central do Brazil released guidelines in May 2021. Key goals include privacy, security, interoperability and cross-border payments. Brazil's instant payment system, PIX, gained popularity, used by nearly 70% of the population by early 2022. A mockup integrating Digital Real, crypto and traditional services was shared in November 2022. Public pilot expected in 2023. Globally, 11 countries launched their own digital currency with China's e-CNY leading. Many Asian countries are in the pilot phase. 32 countries, including the US and Brazil are in the development phase, while 36, including Pakistan and Mexico are in the research stage. Forty-seven countries target retail CBDC's eight focus on wholesale and twenty-one implement both.

India's CBDC Project

India announced the CBDC in the 2022 Union budget, with the RBI releasing a concept note on the digital rupee in October 2022. The e-rupee (eRs.) is a digital version of the Indian Rupee, with both wholesale and retail versions proposed. Unlike crypto, e-rupee is issued and controlled by the RBI and users can't mine it. It maintains a one-to-one parity with the rupee. Anonymity in transactions is addressed through partial anonymity for small transactions. Concerns about value and interest payments are still under RBI consideration to ensure stability in the financial system.

Benefits of CBDC in India

1. Reduces currency cost and settlement risk, saving on security printing expenses.
2. Enhances payment system efficiency and spurs innovation.
3. Aids in promoting financial inclusion.
4. For RBI, the challenge lies in scaling CBDC for widespread acceptance and utility.

How the Pilot Stage Works in India

In 2022, RBI allowed nine banks with rupee and government bond accounts to implement CBDC. They need to establish a direct connection to RBI's CBDC server through their own server using DLT or block chain technology, bypassing intermediaries.

Who Can Use the Retail CBDC?

The first phase of the retail CBDC pilot includes select locations and banks in a closed user group involving both customers and merchants. Initially, it covers Mumbai, New

Delhi, Bengaluru and Bhubaneswar with plans to expand to other cities. The four initial banks are SBI, ICICI Bank, Yes Bank and IDFC Bank with four more banks to join later.

What Will the Retail Rupee Be?

Retail digital CBDC is the electronic form of cash, designed for person-to-person transactions, accessible to all, including private sector, individuals and businesses. RBI aims to spread digital rupee usage across India, ensuring secure payments and settlements. This electronic version prevents fraud and curbs black money circulation due to detailed recording.

How the CBDC is Different from the Current Monetary System

Currently, banks trade with CCIL for net settlements, taking over a day. In the CBDC pilot, banks exchange money directly, allowing for real-time gross settlements. After successful testing with nine banks, this system may expand to all, including government and corporate banks, eventually reaching retailers. This digital transfer technology promotes financial inclusion and aids in efficient cross-border transactions, benefiting individuals and corporations alike.

Conclusion

Digital payment systems are expanding access to financial services, particularly for unbanked individuals. However, they bring challenges like cybersecurity, compliance with regulations and preventing illicit use. Nations are actively exploring their own digital currency - a CBDC - to address these issues. The study covers CBDC design, implications for monetary policy and global CBDC expansion. India is currently in the pilot stage of CBDC implementation.

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A Study on Socio-Economic Condition of Aari Workers in Nagercoil Corporation of Kanniyakumari District

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ABSTRACT

In India many afford have been made from time to time to study the socio-economic conditions of Aari workers in organized and unorganized industries. The present study aimed to assess the work pressure and health issues among Aari workers. They are under pressure to keep up with the production demands. It also shows that most of the Aari workers are having health issues. The aim of the study has been to improve the economic condition and to reduce the health problems faced by the Aari workers.

Keywords: Aari workers, Embroidery, Organized, Health issues

Introduction

Aari work is a type of embroidery which is done on a stretched fabric and stitching the design with a long needle which has a hook in the end. The needle technique originates from the mocha community, who use this type of needle to stitch intricate patterns on leather footwear, the needle is named as Aari, from which the embroidery work derives its name as Aari work. This work consists of beads, stones, golden and silver threads which gives a royal richness to the design. Aari work is known for its elegant thread work that enhances the gravity of hand embroidery. Aari gets its name from the 'Aar', which is a small, hooked needle or awl used by the craftsmen. First, the pattern is carefully traced on transparent paper by a specialized artisan. Perforations are made along the outlines and the paper is placed on the fabric. A special chalk is rubbed over the paper, imprinting the pattern on the fabric below. The fabric is mounted on a rectangular, wooden frame and the embroidery process begins.

Role of Aari Workers

- ❖ Aari workers create artistic designs using special stitching techniques to decorate fabrics and garments by hand or with the help of a machine.
- ❖ An Aari work is an occupation which involves the handling, operating, or fixing of machines.
- ❖ An Aari worker may also perform other duties related to the sewing trade.

Problems of Aari Work

- ❖ **Time consuming:** Hand embroidery is a laborious process that can take days, weeks, or even months to complete a single project.
- ❖ **Limited by design size:** Hand embroidery is limited by the size of the design; it can be hard to embroider large designs with hand.
- ❖ **Skill level needed:** Hand embroidery requires a certain level of skill to create the desired effect.

Methodology

A suitable methodology is necessary for any scientific analysis. The objectives and data interpretation of a problem cannot be done without research methodology. There are various methods to conduct research study. This feels that questionnaire methods are more suitable. In this method researcher prepare different questions, and collected information from 50 sample respondents. Also, the researcher adopts sampling methods to conduct the study.

Objectives

- ❖ To know the socio-economic condition of Aari workers.
- ❖ To examine the problems faced by Aari workers.

Data Analysis

This study deals with an analysis of “A Study on Socio-Economic Condition of Aari Workers in Nagercoil Corporation of Kanniyakumari District”. It is based upon both primary and secondary data. This is collected from Aari workers.

1. Age wise composition

Age is an important factor that influences the productive capacity of the workers. The sample respondents are unevenly distributed among different age group. The following table 1 shows the age wise composition of the sample respondents.

Table 1. Age wise composition of the sample respondents

Age (in years)	No. of. Respondents	Percentage
21-30	22	44
31-40	12	24
41-50	10	20
Above 50	6	12
Total	50	100

Source: Primary data

Table 1 shows that 44 per cent of the sample respondent belongs to the age group of 21-30 years and 12 per cent of the sample respondents belong to the age group of above 50 years. From this it is understood that maximum respondents are youngsters and they are the bread winners of the family.

2. Work experience

Experience shows one's efficiency in job. The sample respondents have many years of experience. This will certainly reduce the risk in their job. Table 2 shows the work experience of the sample respondents.

Table 2. Work experience of the sample respondents

Work experience (in years)	No. of. Respondents	Percentage
Below 1	6	12
1-3	12	24
3-5	10	20
5-7	7	14
More than 7	15	30
Total	50	100

Source: Primary data

Table 2 shows that 30 per cent of the sample respondents are having more than 7 years of experience and 12 per cent of the sample respondents are having less than 1 year of experience. It clearly reveals their active participation in Aari work.

3. Monthly income

An income is an amount of money or compensation paid to an employee by an employer in return for work performed. It is an important determining factor of the status of a family. Table 3 shows the monthly income of the sample respondents.

Table 3. Monthly income of the sample respondents

Monthly income (in Rupees)	No. of. Respondents	Percentage
5000-10000	10	20
10000-15000	18	36
15000-20000	14	28
Above 20000	8	16
Total	50	100

Source: Primary data

Table 3 shows that 36 per cent of the sample respondents are earning Rs.10000-15000 as their monthly income and 16 per cent of the sample respondents are earning more than Rs.20000 as their monthly income. It is understood that according to their work capacity they are rewarded.

4. Health issues

Health issues refer to the health problems faced by the workers. It may be physical or mental. Aari workers face many health problems due to their heavy work. Table 4 shows the health issues faced by the sample respondents.

Table 4. Health issues faced by the sample respondents

Health issues faced by the sample respondents	No. of. Respondents	Percentage
Body pain	15	30
Head ache	9	18
Back pain	18	36
Other problems	8	16
Total	50	100

Source: Primary data

Table 4 shows that 36 per cent of the sample respondents are facing back pain and 16 per cent of the sample respondents are having other problems like vision related problems, numbness in fingers and so on. It clearly shows that the respondents are facing so many health issues due to heavy work they are undergoing daily.

Findings

1. Forty-four per cent of the sample respondents belong to the age group of 21-30 years.
2. Thirty per cent of the sample respondents are having more than 7 years of experience.
3. Thirty-six per cent of the sample respondents are earning Rs.10000-15000 as their salary.
4. Thirty-six per cent of the sample respondents are facing back pain as their health issue.

Suggestion

- ❖ Aari workers should be provided marketing linkages, both in the local and international market.
- ❖ Raw materials should be easily available for the Aari workers, and the cost of raw materials should be affordable.
- ❖ Government should provide schemes for Aari workers to improve their standard of living.

Conclusion

Aari work is a crucial aspect of fashion design that offers numerous benefits, which includes achieving the perfection, creating new designs, and enhancing the overall quality of garments. Aari workers should also stay up to date with the latest trends and developments to ensure that their designs are relevant and appealing to their target audience in order to reduce the health issues and work pressure, the working hours of the Aari workers should be reduced.

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Customer Awareness and Application of Green Banking Practices

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ABSTRACT

It is widely agreed that one of the most important issues facing the globe today including India is environmental conservation. These places pressure on the financial services industry as well as all other economic sectors to undertake "green" projects that provide eco-friendly services. Financial and banking organizations can be proactive by reducing the amount of paper they use and introducing the concept of "green banking" to their multi-branch places. This study examines how consumers regard green banking practices. This study focuses on the awareness of green banking among the public, expanding the environmental issues due to lack of green banking initiatives, and the types of banking activities started to safeguard the environment to reduce the carbon footprints. It evaluates the elements impacting consumer demand for and use of green banking products, as well as the advantages of such practices for consumers.

Keywords: *Green Banking, Customer awareness, Green Banking Initiatives, Carbon Foot prints*

Introduction

In an era where environmental sustainability has become a paramount concern, industries across the globe are increasingly embracing eco-friendly practices to mitigate their ecological footprint. Among these, the banking sector plays a pivotal role in fostering sustainable development through the adoption of "Green Banking" initiatives. Green banking encompasses a spectrum of environmentally responsible practices aimed at reducing the ecological impact of banking operations, investments, and services. Many banks have begun focused on offering green products [1]. This study explores into the field of customer awareness and application of green banking practices, seeking to understand the extent to which individuals are cognizant of environmentally friendly banking options and the factors influencing their adoption [2]. As consumers become more environmentally conscious, there is a growing expectation for financial institutions to align their operations with sustainable principles.

The rationale behind this research lies in the potential of green banking to not only benefit the environment but also to create value for customers and society at large [3]. By incorporating sustainability into their financial activities, banks can facilitate the transition

towards a greener economy while simultaneously enhancing their reputation and competitiveness. Exploring customer awareness entails examining the level of knowledge individuals possess regarding green banking initiatives, including products such as renewable energy financing, green loans, and environmentally responsible investment portfolios. Furthermore, understanding the factors that drive or hinder the adoption of these practices is crucial for banks to tailor their strategies effectively [4].

This research aims to fill existing gaps in literature by providing insights into the attitudes, perceptions, and behaviours of customers towards green banking. By doing so, it seeks to offer recommendations for banks to enhance their sustainability initiatives, engage customers more effectively, and contribute towards a more environmentally sustainable future. This study aids in determining the green banking practices and applications are known and understood by customers.

Green Banking Practices in Banks

In India, the concept of green banking has gained traction in recent years as part of the country's broader sustainability efforts. Various green banking practices have been implemented by banks and financial institutions to promote environmental sustainability and support the transition towards a low-carbon economy. Some of the key green banking practices in India include:

1. **Financing Renewable Energy Projects:** Banks provide loans and financial assistance for the development and deployment of renewable energy projects such as solar, wind, hydro, and biomass [5]. These projects contribute to reducing carbon emissions and increasing the share of clean energy in India's energy mix.

2. **Green Loans:** Banks offer specialized loan products designed to finance eco-friendly initiatives such as energy-efficient technologies, green buildings, sustainable agriculture, and clean transportation. These loans often come with preferential terms and lower interest rates to incentivize borrowers to adopt environmentally sustainable practices.

3. **Carbon Credits Trading:** Some banks facilitate carbon credits trading, allowing companies to buy and sell carbon credits to offset their carbon emissions. This mechanism encourages businesses to invest in emission reduction projects and supports India's commitments to mitigate climate change.

4. **Environmental Risk Assessment:** Banks conduct environmental risk assessments to evaluate the environmental impact of their lending and investment activities. By integrating environmental considerations into their risk management frameworks, banks aim to avoid financing projects with adverse environmental impacts and promote sustainable development.

5. Green Bonds: Banks issue green bonds to raise funds for environmentally sustainable projects and initiatives. Green bonds are earmarked for investments in renewable energy, energy efficiency, sustainable infrastructure, and other environmentally beneficial projects, attracting investors seeking to support sustainable development.

6. Sustainable Investment Funds: Banks offer sustainable investment funds and portfolios that prioritize investments in companies with strong environmental, social, and governance (ESG) performance. These funds allow investors to align their financial goals with their environmental values while promoting responsible investing practices.

7. Environmental Education and Awareness: Banks conduct awareness campaigns, workshops, and educational programs to educate customers and employees about environmental sustainability issues and green banking practices. By fostering environmental literacy and awareness, banks aim to encourage sustainable behavior and promote the adoption of green banking products and services.

Overall, these green banking practices reflect India's commitment to promoting environmental sustainability and addressing climate change challenges. By integrating environmental considerations into their operations and financial products, banks play a crucial role in driving the transition towards a greener and more sustainable economy.

Review of Literature

The term “green” has a wide use and has been in popular discourse due to global outcry for environmental preservation and against climate change impacts. Globally there are several similar if not overlapping definitions of green banking, which are mostly associated with environmental, social, and governance (ESG), corporate social responsibility (CSR), and sustainable banking. They all have some direct bearing on the kind and scope of activities undertaken by banks, not limited to reporting or compliance requirement [6]. The banking sector is regarded as one of the key sources of funding for industrial projects that generates maximum carbon dioxide emissions via steel, paper, cement, pesticides, fertilizer, electricity, and textiles [7]. Creating awareness of green banking is more than just becoming environment-friendly as it is associated with lots of benefits like reduction in the risk as well as the cost of the bank, enhancement of banks reputations and contribution to the common good of environmental besides enhancing the reputation of the bank. In a broad sense, green banking serves the commercial objective of the bank as well as the corporate social responsibility [8] 2015). Steps taken to create environmental awareness has created Green brand image amongst our ecofriendly customers [9]. Environmental awareness can be

included in green banking [10]. With the strong recommendation of many reviews the researcher willing to analyse the awareness of green banking products and services [11].

Statement of the problem

Banking sector is also one of the industries indirectly cause inner and outer emission of carbon footprints. These days, banks are adopting eco-friendly practices because to their sophisticated technology. Banks provide their clients with more environmentally friendly goods and services. Owing to a lack of environmental concern, clients continue to use traditional banking methods, causing pollution in the environment when they travel to banks on two, three, or four wheels. More banks, where employees physically labour, waste a great deal of energy. To overcome these challenges, there is a significant need for concerted efforts from financial institutions, regulatory bodies, and advocacy groups to enhance consumer awareness on green banking. With the aim to reduce the inner and outer emission of carbon footprints, the study was conducted. The purpose of this research paper is to explore the awareness of green banking.

Objectives

The general objective of the study is to measure the degree of customer's knowledge of the implemented green banking products and services among sample respondents. The following are specific objectives of the study.

1. To identify application of green banking practices.
2. To analyze the awareness of green banking products and services.

Methodology

The present study is empirical study and data collection is done on the basis of primary data through a self-made questionnaire. The researcher collected the data from 312 sample respondents from Nagercoil Town for the study. For selecting the sample respondents, simple random sampling technique has been adopted. Statistical Package of Social Science (SPSS) was used for analysing the data. Primary data were collected with the help of structured questionnaire. The data were collected from 312 samples from Nagercoil town. In order to carry out statistical enquiries a questionnaire was prepared comprising age, gender, educational qualification, income, application of green banking products and services and awareness of green banking products and services. Secondary data were collected from various books, journals, reports, thesis, websites and publications of the various government organizations of India and abroad.

Hypothesis

Ho: There is no significant mean difference between the age and awareness of green banking product and services among the sample respondents.

Data Analysis and Discussion

After collecting the primary data, the interview schedules were classified and arranged and the master table was prepared. Data were organized and tabulated for further analysis. Percentage analysis was used to measure the age, gender, educational qualification, monthly income of the family, and application of green banking. ANNOVA test is used to study the awareness of green banking products and services.

Table 1. Demographic profile of the Respondents

Variables	Particulars	No. of Frequency	Percentage
Age	Below 20 Years	76	24.4
	21 to 40 years	84	26.9
	41 to 60 years	78	25.0
	above 60 years	74	23.7
	Total	312	100
Gender	Male	162	52
	Female	150	48
	Total	312	100
Marital status	Married	178	44.2
	Unmarried	134	55.8
	Total	312	100
Occupation	Employee	104	34.6
	Business man	6	2.0
	Professionals	38	12.7
	Others	152	50.7
	Total	312	100
Monthly Income	Below Rs.10000	138	46
	Rs.10001 – Rs.30000	46	15.3
	Rs.30001 – Rs.50000	52	17.3
	Above Rs.50001	34	11.4
	Total	312	100

Educational Qualification	Less than SSLC	28	9.0
	Higher secondary	90	28.8
	Degree holders	170	54.5
	Professionals	14	4.5
	Technical education	10	3.2
	Total	312	100

(Source: Primary Data)

Table 1 shows that 26.9 per cent (84) respondents belong to the age group of 21-40, 52 per cent (162) of the respondents are males. The marital status of the calculated table shows that 56 percent are married and 44 percent of the respondents are single. The occupation of the sample respondents is mostly in the category of salaried and business people with the percent of 30. The majority of the sample respondents are under the income group of Rs.10001- Rs.30000 with 37 percent. The educational qualifications of the sample respondents are shows that majority of the respondents are degree holders with 55 percent.

Application of Green Banking

Green banking was initially introduced in the year 2009 in State of Florida. In India, SBI (state bank of India) being the largest commercial bank took a lead towards setting higher standards of sustainability and undertook foremost step towards “green banking” initiative. In this study the researcher studied how long the respondents started to use green banking services and initiatives.

Table 2
Application of Green Banking Practices

S. No	Period of Using	Frequency	Percent
1.	less than one month	38	12
2.	less than one years	108	35
3.	less than one to two years	56	18
4.	more than two years	76	24
5.	more than five years	34	11
6.	Total	312	100

(Source: Primary Data)

The application of green banking practices represents a fundamental shift in the financial sector towards promoting environmental sustainability and addressing climate

change challenges. By integrating environmental considerations into their operations, products, and services, banks play a crucial role in facilitating the transition towards a low-carbon and resource-efficient economy. From financing renewable energy projects and promoting energy efficiency to supporting sustainable agriculture and green building initiatives, green banking encompasses a diverse array of financial offerings aimed at mitigating environmental impacts and promoting sustainable development. Through the application of green banking practices, financial institutions not only contribute to reducing greenhouse gas emissions and environmental degradation but also create opportunities for sustainable growth, innovation, and social responsibility. In this study, the calculated data shows that application of green banking practices less than one year ranks the first place with the percent of 35. So, it was inferred that a strong initial interest and rapid uptake of green banking initiatives, highlighting the potential for accelerated progress in promoting environmental sustainability within the banking sector.

Awareness

The one-way analysis of variance is used to determine whether there are any statistically differences between the means of two or more independent unrelated groups although one tends to see when there is a minimum of three rather than two groups.

Ho: There is no significant mean difference between age and awareness about green banking product and services among sample respondents.

Table 3. Age and Awareness

Factors	Age group (in years)				F value	P value
	BELOW 20	21-40	41-60	60 ABOVE		
Online banking	.974 (3.39)	1.043 (3.71)	.916 (3.72)	1.040 (3.97)	2.127	.000**
Mobile banking	.900 (4.00)	.790 (4.10)	.725 (4.00)	.683 (3.76)	1.322	.002**
Debit card	.788 (3.97)	.660 (4.17)	.751 (4.26)	.880 (3.95)	1.466	.000**
Credit card	1.127 (2.97)	1.078 (3.24)	.903 (3.36)	.939 (3.30)	1.061	.001**
Electronic Clearance System	1.266 (3.47)	1.172 (3.57)	1.328 (3.36)	1.366 (3.54)	.240	.068
Tele banking	1.018 (2.79)	1.061 (2.60)	1.128 (2.87)	1.134 (2.78)	.477	.070
Customer Integrated System	.978 (2.55)	1.055 (2.36)	1.108 (2.67)	1.294 (2.86)	1.435	.023*
National Electronic	.733 (3.95)	.731 (4.05)	1.010 (3.92)	.983 (4.08)	.297	.082

Fund Transfer						
Real Time Gross Settlement	1.010 (4.18)	.932 (4.24)	.902 (4.14)	1.182 (4.20)	.085	.000**
Immediate Payment Service	.999 (3.47)	.951 (3.36)	.879 (3.38)	1.091 (3.35)	.137	.094
Withdrawal without using debit card	.811 (4.13)	.814 (4.14)	.821 (4.10)	.799 (4.03)	.157	.092
Point of Scale	.622 (4.21)	.808 (4.07)	.894 (4.21)	.751 (4.14)	.288	.000**
Scan and pay	.963 (4.21)	1.017 (4.12)	.951 (4.13)	.838 (4.27)	.221	.000**
Cash depositing through machine	.973 (3.84)	.883 (4.00)	1.012 (3.77)	.764 (4.16)	1.387	.001*
Green loans	1.146 (3.34)	1.265 (3.24)	1.255 (3.28)	1.022 (3.89)	2.536	.005**
Online insurance	1.155 (3.74)	1.110 (3.50)	1.046 (3.90)	1.199 (3.70)	853	.046*
Green cards	1.293 (2.71)	1.220 (2.69)	1.321 (2.87)	1.252 (2.65)	228	.087
Carbon insurance	1.038 (4.05)	.683 (4.14)	1.026 (4.00)	.764 (4.16)	.286	.083
Green deposits	1.004 (3.58)	1.018 (3.52)	1.009 (3.33)	1.002 (3.32)	.646	.058
Remote deposit	.623 (1.87)	.969 (2.19)	.807 (1.92)	.866 (2.16)	1529	.054
Green pin	.725 (3.53)	.737 (3.57)	.864 (3.21)	.985 (3.41)	1538	.062

(Source: Primary data)

Note: ** Denotes significance at 1 percent level.

Discussion

Since the P value is less than 0.01; null hypothesis is rejected at 1 percent level of significance with online banking, debit card, Real Time Gross Settlement, point of scale, scan and pay. Hence there is a significant difference among age group of the respondents. The P value is more than 0.05, null hypothesis is accepted at 5 percent level with regard to awareness of credit card, customer integrated system, cash depositing through cash deposit machine, green loans, online insurance. There is no significance difference between the awareness regarding the age group of the factor green cards, carbon insurance, remote deposit, and remote deposit above at 5 percent level. The above study was agreed with Rupali

Satsangi and Paned Kaur (2021), the results of their study indicated that the banks are using green banking practices and many of the respondents are unaware of the green banking practices, Catherine and Jeba Melvin (2020) also related to this study their findings reflected as there is no significant difference in awareness of green banking products of green loans among various age group of bank customers.

Findings

- ❖ The study reflected that 52 percent of the respondents are male and 48 percent of the respondents are female.
- ❖ The marital status of the respondents is categorized as 87 percent of the sample respondents are married and 69 percent of the respondents are single.
- ❖ The educational qualifications of the sample respondents are shows that majority of the respondents are degree holders with 55 percent.
- ❖ The occupation of the sample respondents is mostly in the category of salaried and business people with the percent of 30.
- ❖ Majority of the sample respondents are under the income group of 10001-30000 with 37 percent
- ❖ Application (using) of green banking practices less than one year ranks the first place with the percent of 35.
- ❖ There is no significance difference between the awareness regarding the age group of the factor green cards, carbon insurance, remote deposit, and remote deposit are at above 5 percent level. The study's findings showed that banks are implementing green banking techniques, however many of the respondents were not aware of techniques.

Suggestions

- ❖ The bank should encourage women customers to use green practices.
- ❖ The researcher also suggested, new innovative practices are to be encouraged to practice by the customers by providing certain rules and regulations by the RBI.
- ❖ Banks should create awareness among consumers about the innovative green banking practices like Solar ATM, Carbon Insurance, and Green securitization.
- ❖ The consumers should reduce the application of traditional banking;instead, the consumers will take a step to move towards green banking.

Conclusion

In the field of finance "Green banking" has been around, for long time but there seems to be a lack of awareness regarding sustainable banking practices. It is important for the RBI to educate and promote awareness about banking as it encompasses all friendly activities

within the banking sector. It's worth noting that simply adopting advancements in banking does not automatically qualify as banking. Green finance on the hand is a concept that brings numerous benefits, to both customers and banks alike. Its objective is to ensure sustainability and foster positive outcomes in every aspect of banking transactions. Since we are in the beginners of green banking, it is the duty of RBI to introduce more regulatory reforms which benefited to customers and safeguard our environment.

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From Silence to Resilience: Breaking the Boundaries of Suppression in The Woman Warrior by Maxine Hong Kingston

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ABSTRACT

*Across cultures and throughout history, the silence of women has been a pervasive and complex phenomenon. This silence manifests in various ways, from the lack of female voices in positions of power to the societal expectation for women to remain demure and submissive. Understanding the various facets of this silence is crucial to recognizing its impact on women's lives and in working towards a more equitable future. The memoir *The Woman Warrior* navigates the complex interplay between cultural identity, femininity and the quest for self-expression. The narrative unfolds as a poignant exploration of silence, both imposed and self-imposed, and the subsequent emergence of voices that defy societal constraints. The narrative also blends myth and reality, showcasing the power of story-telling as a means of reclaiming identity and agency. The paper delves into the protagonist's struggle to break free from the silencing forces of tradition, family expectations and social norms. It examines how the woman warrior transcends the boundaries of silence, gradually finding her own voice amidst the cultural expectations. Furthermore, the paper highlights the intersectionality of the gender and ethnicity in the memoir, illustrating how the woman warrior's journey is intricately tied to her Chinese-American heritage.*

Keywords: *Silence, Voices, Cultural identity, Femininity, Self-expression, Talk-stories*

Maxine Hong Kingston's memoir, *The Woman Warrior* delves into the intricate exploration of silence, voices and identity. She raises the complex question of identity in her novels and thereby breaking the barriers of imposed cultural values on women. Her work is the testament of Chinese-American women who have long been marginalised and silenced by both Chinese culture and American society. The narrator speaks not only of the immigrant experience but also of the silenced voices of women in the patriarchal society. This paper entitled "From Silence to Resilience: Breaking the Boundaries of Suppression in *The Woman Warrior* by Maxine Hong Kingston" unveils the profound journey of overcoming silence and finding one's voice, illustrating how the power of narration can become a crucial tool for emancipation.

The silence that permeates *The Woman Warrior* is multifaceted. The silence imposed by Chinese culture and tradition dictates that women should remain obedient and restraint. Kingston's mother represents this archetypal silence as she struggles to conform to these

expectations. The silence represented in the novel, is also a reflection of immigrant experience. Kingston's parents, like many other Chinese immigrant's grapple with the challenges of assimilation in America. The inability to communicate effectively in English leads to a form of silence, where their voices are stifled by the language barriers. This silence is the barrier to the integration into American society and serves as a source of internalised shame.

The broader significance of Kingston's exploration of silence to voices lies in her portrayal of the immigrant experience as a profound transformation. It is a journey marked by the struggle to find one's voice in a new unfamiliar culture while preserving the essence of one's heritage. The immigrants' voices are loved in the sense that they are unapologetically authentic, yet they remain unmodulated to the American context.

Kingston unveils voices from the past through a series of mythical talk-stories which get passed down through generations. These stories serve as the bridge between Chinese heritage and the American reality. One such tale is the legend of Fa Mu Lan, the female warrior who defies traditional gender roles and societal expectations. This story empowers Kingston and her mother, Brave Orchid who envision themselves as more than just silence conformists. Fa Mu Lan voice resonates through the generations inspiring them to break-free from the constraints of silence and find their own voice. Kingston also explores the voices of the ancestors through her mother's tales. These stories provide a connection to their Chinese roots and reveals the struggles and sacrifices of those who came before them. It is through these narratives that Kingston begins to find her own voice and identity.

Kingston employs story-telling as a means of giving voice to her experiences and to her family as a whole. She blends the reality and myth to create the narrative that transcends the boundaries of silence. By weaving together personal anecdotes, family history and Chinese folklore, Kingston constructs a complex and multifaceted narrative that challenges conventional notions of identity. Through story-telling, Kingston transforms the silence into a powerful voice that resonate the readers. Her narrative becomes a testament to the strength of the immigrant experience in alien land.

In the opening chapters of the memoir, Kingston introduces the concept of silence as a cultural construct which is imposed upon Chinese woman. She recounts her mother's admonitions to be silent but not dumb, highlighting the expectations which are placed in typical Chinese society. This silence serves as a means of survival and conformity within the traditional Chinese patriarchal society. Throughout the memoir, Kingston grapples with the haunting presence of the ancestral ghost and the ghost of silence that linger in her family's

history. These ghosts represent the weight of tradition and the unspoken expectations placed upon her as a Chinese-American woman. Kingston's struggle to confront and communicate with these ghosts symbolizes her journey from silence to voices.

The Woman Warrior portrays Kingston's struggle to reconcile her Chinese heritage with her American upbringing. She navigates the dual identity of being a Chinese-American often feeling like an outsider in both cultures. Through the process of story-telling, she begins to understand the importance of embracing her roots and finding her own voice within the cultural narrative.

Central to the theme of silence to voice is the notion of names, as exemplified in the quote, "Chinese I know hide their names; sojourners take new names when their lives change and guard their real names with silence" (Kingston 18). The quoted passage emphasizes the practice of Chinese individuals concealing their true names, especially when adapting to new circumstances. Names in traditional Chinese culture are not merely labels but embodiments of one's identity, heritage and destiny. This concealment of names symbolizes the suppression of individual identity in favour of societal norms and expectations.

Kingston illustrates how Chinese immigrants often feel compelled to adopt westernised names as a form of cultural assimilation through her memoir. This process is marked by silence as they hide their original names effectively by erasing the part of their cultural heritage. The silence signifies the loss of their true selves in the quest to fit into American society. As the narrative unfolds, Kingston begins to reclaim her identity. She refuses to be confined by the silence the society imposes on her as a Chinese-American woman. By asserting her name and embracing her heritage, Kingston empowers herself to speak out and share her experiences and those of other marginalised voices.

Kingston's narrative goes beyond the surface-level silence, it delves deep into the inner turmoil experienced by Chinese immigrants, particularly woman who grapple with her dual identities. Kingston's own experiences as the Chinese-American woman provide a lens through which she examines her journey from silence to self-discovery. The silence surrounding one's true name becomes the metaphor for the inner silence and confusion about one's cultural and personal identity.

Throughout the memoir, Kingston explores the practice of "Taking new names when their lives change" (Kingston 18). This act of renaming oneself signifies a pivotal moment of transformation and self-realisation. Throughout the memoir, the readers encounter characters, who in moments of self-assertion reclaim their true names shedding the cloak of silence that

once concealed their identities. This act represents the shift from passivity to agency, from silence to voice.

The phrase “god their real names is silence” (Kingston 18), suggests the importance of protecting one’s true self amidst the pressures to conform or assimilate. Kingston’s female characters grapple with the weight of cultural expectations and gender roles. But they also find strength in their individuality. In their real names, they affirm their right to define themselves on their own cultural context. It is a powerful assertion of autonomy and self-worth.

One of the central themes of the memoir is the idea that “Silence runs even deeper in the work of minority woman” (Kingston 163). In her narrative, Kingston explores how Chinese-American woman cart between the cultures of their heritage and the demands of American society grapple with layer of silence. They are silenced not only by external expectations but also by their own internalised fear and insecurities.

Kingston’s characters particularly her mother Brave Orchid and her aunt Moon Orchid exemplify the base in which silence can manifest the lives of minority women. Brave Orchid’s stoic determination and Moon Orchid’s inability to find her voice after decades of being silence in marriage are poignant examples of the complex relationship between silence and identity. These women are bound by tradition, struggling to reconcile their cultural heritage with the desire for individuality.

One of the most poignant moments in the memoir is when Kingston recounts the story of the “No Name Woman”. This unnamed aunt story is shrouded in secrecy and her silence is enforced through shame and societal judgement. Yet, Kingston refuses to let her aunt’s story remain untold. She gives her aunt a voice rescuing her from historical oblivion and affirming the importance of acknowledging the silenced voices of the past.

The passage, “The immigrants I know have loud voices, unmodulated to American tones even after years away from the village where they called their friendships out across the fields” (Kingston 18), encapsulates the profound tension between silence and voice that permeates the lives of immigrants. This tension is an emblematic of the struggle to reconcile their heritage and upbringing with the demands of their new environment.

The Woman Warrior explores the silence imposed on individuals, particularly women within a patriarchal and culturally traditional society. The silence can manifest in various forms, from stifling personal emotions to suppressing individual voices due to societal expectations and fear of retribution.

Sniffling and snorting, I couldn't stop crying and talking at the same time...It seemed as if I had spent my life in that basement, doing the worst thing I had yet done to another person. 'I'm doing this for your own good, I said. Don't you dare tell anyone I've been bad to you. Talk. Please talk (Kingston 181).

In the aforementioned passage, Kingston grapples with the emotional turmoil of their actions and also the desperate plea for the other people to talk despite their own distress. This scene illuminates the theme of silencing one's own emotions and experiences. In the provided passage, the narrator is caught in a moment of inner conflict where they are emotionally overwhelmed sniffling and crying yet struggling to communicate. This struggle represents the internal silencing of their emotions and trauma. The act of crying and talking simultaneously symbolizes the attempt to express oneself while being stifled by the weight of silence.

The narrator's insistence on the other person talking despite the narrator's own distress underscores the importance of breaking the silence. The plea "Don't you dare tell anyone I've been bad to you. Talk. Please talk" (Kingston 181), reveals a complex relationship with the societal expectations that perpetuate silence. There is a desire for the immigrants to speak up, to break a silence and yet it is clouded by fear and the consequences of challenging established norms. This struggle to communicate and break the silence is reflective of the broader struggle which women face in a patriarchal society, where voices are often suppressed or dismissed. The act of imploring the other person to talk can be seen as a metaphor for the author's desire to empower individuals to speak up and share their experiences, ultimately challenging the oppressive silence that confines them.

Martin Ray in her work entitled "Language and Silence in the Novels of Joseph Conrad" says that "Silence must indeed appear an attractive if paradoxical alternative for the writer haunted by the inadequacy of language, and the promise of cathartic release which silence holds has influenced many writers' attitudes to language in the past two centuries" (19). Martin Ray addresses that silence has influenced the role of writers in the past two centuries. Kingston too acknowledges the importance of silence and has recorded the influential role of silence in her literary expressions.

Kingston explores how silence can be a powerful source shaping individual and collective identities, particularly in the context of cultural expectations and family dynamics. The line, "you must not tell anyone," my mother said, "what I am about to tell you. In China your father had a sister who killed herself. She jumped into the family well. We say that your father has all brothers because it is as if she had never been born" (Kingston 3) represents a directive from Kingston's mother urging her daughter to maintain secrecy about certain

family stories and cultural truths. This directive reflects the weight of cultural expectations and the pressures to conform to the social norms. The silence enforced by the mother is a mechanism to preserve family honour, protect the family from the potential justice or scrutiny from the outsiders and other to Chinese traditions.

Mekada Graham in her paper entitled “Changing Paradigms and Conditions of Childhood: Implications for the Social Professions and Social Work” addresses that “Taking a social constructivist approach, sociologists have accorded children with conceptual autonomy and the primary unit of study as social persons in their own right, which emphasises children's own voices as most reflective of their selves, their lived experiences and their social realities” (1535). Mekada highlights the voices of children as the most authentic expression of their identity, encompassing their lived experiences and social contexts. Likewise, Kingston throughout the memoir, grapples with the silence contemplating its impact on her identity and the broader implications for her place in both Chinese and American cultures. The enforced silence stifles her voice, hindering her ability to fully understand her heritage and express her personal experience and emotions right from her childhood. The social context, lived experiences of Kingston enumerates the authentic realities of their self.

Kingston also begins to question the challenge in these silences. As she navigates her own cultural identity as a Chinese-American, she seeks to break-free from the constraints of silence and find her voice. Writing *The Woman Warrior* becomes an act of defiance and empowerment, where she reveals the untold stories by bringing them to light despite the taboos associated with sharing them. By breaking the silence and by narrating all her experiences, Kingston engages in the process of liberation and healing. She sheds the burden of silence and paves the way new narrative, one that is honest, authentic and unapologetic. Through this act of reclaiming her voice she not only transcends the constraints of silence but also gives a voice to other silenced stories within the culture.

The concept of silences in their transformation into voices holds significant literary and cultural implications. The specific passage, “my silence was thickest-total-during three years that I covered my school paintings with black paint...layers of black cover houses and flowers and suns” (Kingston 149), provides rich insight into this theme. Here, the silence symbolizes not merely an absence of speech but a suppression of identity and expression. Kingston’s act of covering her school paintings with the layers of black paint encapsulates the silencing of her voice, heritage and artistic inclination. The black paint becomes a metaphoric shroud, concealing vibrant aspects of the culture and individuality. The choice of black paint

carries symbolic weight. Black is often associated with darkness and void and represents the stifling of voice, creativity and cultural heritage. Kingston conveys her sense of suffocation and erasure of her cultural roots, personal experiences and artistic expressions.

The three-year duration emphasizes the endurance of the silence and the prolonged struggle she faced in confronting her silenced identity. It showcases the depth of the internalised societal expectations, cultural norms or personal fears that lead to such an extended period of stifling one's voice. However, Kingston's act of narrating this silence faced in her life within *The Woman Warrior* itself represents a transformative journey. By putting her experiences in her works, she is metaphorically feeling off the layers of black paint and letting her silenced voice resurface. The act of story-telling becomes a means of reclaiming her voice and culture, breaking the silence and offering a counter-narrative to societal expectations.

The theme of transitioning from silences to find one's voice is a pivotal aspect of the narrator's journey. "I enjoyed the silence reminiscences the narrator, but later finds out that she had to talk and that school became a misery" (Kingston 166). The quote, "I enjoyed the silence" (Kingston 166) encapsulates the initial contentment the narrator finds in withholding her voice, perhaps as a coping mechanism or a reflection of a cultural norm she grew up with. Silence in this context represents the narrator's attempt to conform to the societal expectations and preserve a façade of composure or obedience. The quietude offers a retreat from potential scrutiny or judgement, providing a temporary sense of security. It is a refuge from the challenges and complexity that arise when one speaks out, particularly in a cultural milieu that imposes rigid expectations on women and behaviour.

The silence projected in the memoir, eventually reveals its impact on the narrator's growth and wellbeing. The realisation that she must use her voice and express herself creates a profound shift in her perception. The quote "that school became a misery" (Kingston 166), highlights the discord between the initial enjoyment of silence and the subsequent agony that arises by stifling one's voice. The transition from embracing silence to finding her voice signifies the journey of self-discovery. It is a path marked by grappling with cultural and personal expectations ultimately leading to the understanding that true strength lies in embracing and utilizing one's own voice. This transformation reflects a broader theme of cultural and personal identity that Kingston explores throughout the memoir, illustrating the importance of breaking free from stifling traditions and finding one's unique voice in order to achieve authenticity and fulfilment.

The notion of silence and its transformation holds profound significance, particularly concerning the line, “silence had to do with being a Chinese girl” (Kingston 166). This line encapsulates the struggle and eventual liberation of the protagonist, reflecting broader themes of cultural identity, gender roles and the immigrant experience. The silence alluded in this line refers to the cultural silencing imposed on Chinese girls and women within the societal context on that time. This silence eliminates from the traditional Chinese values and patriarchal structure that stifled female voices and relegated them to subservience. Chinese culture with its emphasis on humility and restraint, expect women to maintain silence and conform to societal expectations.

In *The Woman Warrior*, Kingston grapples with breaking free from the suffocating silence. The transformation from silence to voice signifies a process of embracing her identity as a Chinese-American woman, overcoming societal expectations and finding her own narrative. As Kingston navigates her dual identity, she uncovers power in her voice and the stories she tells. By breaking the silence, she not only liberates herself but also reshapes her cultural narrative. Kingston uses her voice to shed light on her untold stories of Chinese-American women, challenging stereotype and advocating for a re-evaluation of cultural norms that sort to keep them silent. Kingston through her deeply personal accounts, demonstrates that finding one’s voice amid societal silence is a collective triumph, ultimately paving the way for a more inclusive and just society.

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Breaking Bond: A Portrayal of Familial Relationship in Jeannette Walls's *The Glass Castle*

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ABSTRACT

*The paper entitled "Breaking Bond: A Portrayal of Familial Relationship in Jeannette Walls's *The Glass Castle*" is an attempt to highlight the struggles that the author has faced in her life for being poor. She is forced to stay on the beach, railway station, streets and also in deserts due to poverty. As financial crisis struck her family, she and her family members are imposed to move to different parts of the country for a better living. This paper also focuses on the challenges faced by the author, her brother and her sister during their migration. The Walls children had to be the parents of the house most of the time because Rose Mary and Rex are never at home which raised them to be independent and do everything on their own. Some choices they have to make as adults are mostly about what they are going to get for food, how to spend their money, and when they live on their own in New York City.*

Keywords: *Life, Poverty, Hunger, Food, Shelter, Family*

Poverty is something that should be eradicated from the society. Even today there are many people who suffer a lot because of poverty. Poverty arises when there is a lack of money to afford the basic needs of a person. In order to eradicate poverty, one should work hard and earn money. Bertold Brecht says that "poverty makes you sad as well as wise", this means that people may suffer due to poverty but still it makes people wise. On being wise one can overcome the problem of poverty. The other cause of poverty is unemployment.

In this novel *The Glass Castle*, poverty arises with unemployment. As the father of Jeannette Walls, Rex Walls is unable to find job, he cannot handle the family properly because he lacks money. Education plays a major role in the novel. Education is something that makes people empowered. Poverty acts as a great enemy to human society. This makes the conditions of the house worst. Rex Walls is too supportive of her daughter, Walls. One of the important reasons for Jeannette's success after being brought up extremely poor is due to the perseverance her father gave her.

Walls along with her siblings helped their father in many ways. Whenever Rex Walls decided to go to other cities in search of a job. Walls and her siblings move to the cities with their father. Rex Walls spent most of his time out of his home, as they did not have enough

money, they worked hard to overcome their obstacles. They even suffered for food. Rex Walls was more interested in adventures. He often says his adventurous stories to his kids and they will be eagerly waiting for such stories.

Rex Walls always returns home with a bag full of food for his kids. As he is incapable of getting a good job, he leaves Jeannette and her siblings to face hunger at many times. Jeannette along with her brother Brian go in search of berries and other food in the woods. They search for food in the cafeteria trash at the school. They try to find their food even in trash cans. When their father return home after his work, he brings food. But Jeannette knows it must be saved for upcoming days, so she says "I guess we can eat less" (67). Even though they struggle for food, their mother is a self-centred woman who cares only about her well-being. She even hides food from her children. They have a coal stove but still, they don't have enough money to buy coal for burning. And so, they cannot cook anything, which makes them stay in hunger. Today all over the world, hunger has been a constant problem for ages. It can be solved easily. Years before hunger arose only at the times of war. But today hunger arises with unemployment. As there is no job opportunity today, people suffer from unemployment and this acts as a stepping stone to poverty. Poverty can be eradicated with limited consumption of food and by avoiding spending money lavishly.

Walls's maternal grandmother is Smith, she is the one who was liked by all. Whenever Walls's family is in trouble, she will help them to overcome such a situation. Walls's mother Rose Mary Walls hates her because she will be strict at times and will be controlling her when she comes up with some mistakes. Walls's mother often says that she hates Grandmother Smith. But Walls loves her because of her kindness and she is the one who loves to take care of Jeannette and her siblings. Jeannette likes her because she will correct her mistakes if she makes any. But Rose Mary Walls ignores the death of Grandmother Smith. When they come to know about her death, Jeannette questions her mother for not informing. Grandmother follows some strict rules to be followed like how to dress, how to cook and how to clean the house etc. At times she may even punish her for disobedience Rose. Rose Mary Walls does not set any kind of rules like Grandmother Smith for her children. Jeannette Walls enjoys having rules. Smith is a strong-willed lady with strict rules for leading a happy and disciplined life.

In the novel *The Glass Castle*, Rose Mary says "God doesn't mind you bending the rules a little if you have a good reason" (111), the attitude towards morality differs from person to person, and also about the moral values. The moral values followed by society were neglected by the family at times. This may differ according to the wishes of people. Morality

is something that is expected to be the same for all, but then it differs. Oscar Wilde says that “Morality is the attitude which we adopt towards something or someone, whom we personally dislike”.

The relationship between Rex Walls and Rose Mary Walls is different. Even though they fight among themselves, the bond between them is strong. Rose Mary doesn't give up Rex Walls in any situation. In the novel *The Glass Castle* represents hope of a family. They dream for a better future. As her father promises them to build a glass castle, it became a dream alone and does not take place in their real life. Though they cannot build real a glass castle at least they dreamed of doing so. This shows the family's hope of being in a good position. The glass castle here comes in order to symbolise the broken promise of Rex Walls. In the novel, we can see that Walls's parents are violent. They neglect to raise their children in a good manner. They do not support their children, and they let them to face the problems. Rex and Rose Mary Walls love each other, but their quarrels make their children. This happens after the consumption of alcohol by her father. They don't follow certain rules and discipline. They lack moral thinking at times. Parents don't share friendly relationship with their children. Most often they quarrel for money. Walls's mother had an art studio and she spends much time there. Rose Mary works as an artist there. As Rex Walls is a man of adventures, he pushes Rose Mary down from the window, unexpectedly she is saved by her children. People around their house mock for their dramatic behaviour.

Walls respects everyone and helps each other in their worst situations. Her father states that the fire accident she meets is a sign of bravery. Jeannette handles the situation with goodwill and bravery. She overcomes the struggle and the fire bravely and confidently. She adopts herself for every obstacle logically. She enjoys the days which she spends in the hospital. Even though she is in pain, she enjoys the days. She makes friends with the nurses who take care of her. Jeannette's mother does not allow her to do what she likes. Through this, the children learn how to live without fear. They are loyal to one another. The children manage to survive in the hot desert too. Walls and her siblings star to enjoy what they have and they support each other in the hardest times. The family manages the hopeless situations with complete desire and they lead a happy life.

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Cancer Journey and Tenacity of Yuvraj Singh in the Novel The Test of My Life

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ABSTRACT

The paper entitled Cancer Journey and Tenacity of Yuvraj Singh in the novel “The Test of My Life” focuses on the journey of his career in which he has battled against cancer and its impact on his life. It also highlights about his ability to bounce back from his series of ups and downs. Yuvraj Singh’s cancer journey underscores not just physical resilience but the tenacity to confront life-altering challenges to maintain a positive outlook and to emerge from adversity. His life acts as an inspiration to many people by illustrating the power of determination of a human spirit in the face of formidable obstacles. This study further looks into the post traumatic growth of his journey.

Keywords: Cancer Journey, Tenacity, Resilience, Mediastinal Seminoma, Post Traumatic Growth

Tenacity refers to a quality or state of being persistent, determined and holding firmly to one’s purpose and goals. The autobiography of Yuvraj Singh’s *The Test of My Life* completely targets on his career, cancer battle and his comeback to cricket. The life of Yuvraj Singh serves as a paradigm of how an individual can find meaning, strength and a new perspective through the crucible of challenging life experience. Yuvraj Singh’s life takes sudden drift when he was recognized with a rare lung cancer called mediastinal seminoma in 2011. “Mediastinal seminoma is a malignant germ cell tumor in the mediastinum. The tumor usually occurs in the anterior-superior mediastinum in males aged 20-40 years old” (Bishop, Kyriakopoulos). The mediastinum is split into three chambers anterior, middle and posterior. It typically arises in the anterior and middle chambers. When it comes to diagnosis of mediastinal seminoma it involves CT scans or MRIs and biopsy to examine the tissue for the presence of germ cells. The primary treatment for mediastinal seminoma typically has an amalgamation of surgery, chemotherapy and radiation therapy.

Chemotherapy is considered to be a key component in directing germ cell tumor and the regimen may vary according to the phase and characteristics of the tumor. Yuvraj Singh’s cancer battle was not only physical but also emotional. He became debilitated from the grueling treatment and his future as a cricketer was at stake. “I would think if it was

cancerous, my God, I wouldn't play cricket any more. Forme, happiness was always playing cricket" (The Hindu).

The distressing journey of experiencing a life-threatening sickness led him to reevaluate his priorities and focus on the holistic aspects of life beyond cricket. A profound change in Yuvi's outlook on life, success and well-being was prompted by his cancer journey. The recovery period divulges his inner strength and resilience during the challenging period of his cancer treatment.

The capability of enduring the physical and emotional toll of his illness and treatment projects the elements of personal growth and tenacity. Yuvraj traveled to the United States for chemotherapy at the Boston Medical Center. During Chemotherapy he experienced side effects like weight loss, fatigue, nausea, hair loss and weakened immune system. After months of rigorous treatment and recovery, Yuvraj Singh emerged victorious over cancer.

Throughout his recovery period he had a huge support system like his family, friends and well-wisher to cope up with. Their encouragement played a vital role in helping him to stay positive and stay focused throughout his healing process. After the chemotherapy sessions he was in recovery period. His successful recovery paved the way for his eventual return to professional cricket marking are markable come back after cancer. His come back to cricket was atestament to his strength and determination. He returned to the field, showing not only his cricketing prowess but also served as a symbol of triumph over adversity.

The post recovery period of Yuvraj Singh cancer journey actively engaged in the cancer awareness and advocacy through the You We Can Foundation. It is a non-profitable foundation and its major goal is to raise awareness on cancer, educate the public and to provide the cancer patients with support through a range of campaigns and programs. This dedication to a broader cause illustrates how a personal suffering can positively convert into a goal to assist others which portrays concept of post traumatic growth. His life journey to other cancer patients acts as an inspiration to overcome the struggles.

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Voice of an Unsung Heroine: A Study of Madline Miller's *Circe*

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ABSTRACT

The present paper is an attempt to highlight the predicaments of a mythical character who is a woman and whose sufferings are more or less similar to the miseries encountered by women in the real physical world. The main aim of this research work is encouraging women at all levels to realise their confidence and should be brave enough to voice out their grievances and finding solution for the same. The protagonist in the selected novel namely Circe, after undergoing many sorrows not merely speaks out but fights for her rights and finally prove herself an individual worth to be adorned. Madeline Miller is an American novelist and the author of The Song of Achilles (2011) and Circe (2018). Circe is Miller's second novel which was published on April 10, 2018. The book is a modern reimagining voiced from the perspective of Circe, an enchantress in Greek mythology who is featured in Homer's Odyssey.

Keywords: Grievances, Predicaments, Miseries, Myth, Rights, Voice out.

Myths have given us infinite number of tales that shape and mould human beings from time immemorial. They are filled with fantasy and magic where we find celestial beings who reign over the universe with their infinite power. As mentioned in the book titled *Exploration of Mythological Elements in Contemporary Narratives*:

Mythology is the work of yesterday's unknown authors. These stories, circulating on the infinite limits of the human imagination, are still a source of inspiration for today's writers, despite all the incredible things they contain. These narratives, which envelop the truth in exaggeration and imagination, have been an effective source in bringing the realities of the past to the present. (2)

This paper focuses on one such celestial being who though born as a Titan has to undergo a lot of turmoil both emotional and physical in her odyssey of survival. Femininity is looked upon as a weakness not only in the human realm but also in the celestial abode. The central figure of *Circe* is a female goddess born to Helios and Perse who in her father's palace lives a lonely life deprived of parental love and care.

Circe was the eldest of four children born from the union of Helios and Perse. Right at her birth she was found to be unattractive and was easily handed over to one of her aunts to be taken care of by her mother. When her younger siblings were born, she was even more

ridiculed by her mother and her siblings. “The two of them were clever and quickly saw how things stood. They loved to sneer at me behind their ermine paws. *Her eyes are yellow as piss. Her voice is as screechy as an owl. She is called Hawk, but she should be called Goat for her ugliness*” (6). She as a young entity longed for attention and love which she seldom received. But she always preferred to stay at her father’s feet. “I preferred my father’s quiet halls and spent every second I could at my father’s feet” (6).

Circe was never noticed as an individual. She was lost in the shadows of her brothers and sister. This created in her a yearning to get herself some attention. She was present in the great hall and witnessed Prometheus getting punished for his love towards humanity. Soon after the whipping she went to her uncle Prometheus and offered him nectar to drink. This very act of rebellion was only the beginning for the actions that were yet to come forth from her. The young mind was not able to comprehend matters easily and she could find no one to guide her. She took a dagger and cut her palm. The pain and blood brought into her a sense of new realisation. “I sat watching it, as I watched I found a new thought in myself. I am embarrassed to tell it, so rudimentary it seems, like an infant’s discovery that her hand is her own. But that is what I was then, an infant. The thought was this: that all my life had been murk and depths, but I was not a part of that dark water. I was a creature within it” (19).

Circe found a companionship in her youngest brother Aeetes. He found a deserted seaside and they spend a lot of time together there. Throughout her life, Circe remembered those days that she had spent with her loving brother in the beach. After her exile she met Aeetes only once when Aeetes was pursuing his daughter Maeda. Her brother’s presence was known to her even before she could see his physical being. Such was her love for her sibling. “A pleasure rose in me so old and sharp it felt like pain. My brother” (152).

In spite of her love she was let down by her dear brother whenever she looked up at him for his aid and approval. When the all the four off springs of Helios and Perse were found to be practicing witch craft none got punished except Circe. She was doomed to spend her eternity in the island of Aiaia by Zeus. She expected her brother to stand by her but he deceived her. “A thousand eyes pinned me. I wanted to cry out, to plead, but my breath would not catch. My voice, ever thin, was gone. Aeetes will speak for me, I thought. But when I cast my gaze to him, he only looked back with all the rest” (63).

Circe’s love for mortals was not something that sprouted overnight. Helios her father himself had foretold that she might marry a handsome prince – a mortal. “‘A prince, I think.’ ‘A prince?’ my mother said. ‘You do not mean a mortal?’” (3). She was fascinated by the term mortals. All through the novel we find that unlike most of the Gods and Goddesses

Circe was more concerned about the humans. When the Olympians and Titans were after the prayers and offerings given by humans, Circe was very critical of this attitude. She even expressed her displeasure when people knelt in front of her asking for favours.

In her voyage to crete she had to encounter Scylla the monster of her own creation. She managed to save the crew members from Scylla. The gratitude of the ship men infuriated her. “‘Lady,’ Dedalus said. ‘We will make sacrifice to you every day of our lives for this. . . Such worship was the payment my kind demanded for services rendered’” (102). She reprimanded them and from her words we come to know of her feeling of guilt and also, she pitied the lives that were lost because of Scylla. “The Bile rose in my throat. ‘You fool,’ I said, ‘I am the one who made that creature. I did it for pride and vain delusion. And you thank me? Twelve of your men are dead for it, and how many thousands more to come? That drug I gave her is the strongest I have. Do you understand, mortals?’” (102).

Circe had deep feelings for the humans that interfered with her normal existence. Her affection for Glaucos made her use the Pharmaka on him as well as on Scylla. The transformation of Scylla disturbed Circe and towards the end of the novel we find her going in search of Scylla and transformed her into stone by using the venom of Trygon. “At the base of the cliff, where Scylla had been, was a hulking shoal” (321). Unlike most of the Gods and Goddesses Circle was seen mending the mistakes that she had committed. She never walked away from her commitments. As a mother she fiercely protected her son from Goddess Athena’s wrath. She was so daring that when Telegonus was about to sail to Ithaca she ventured into the deep sea to meet Trygon for his venom tail. When challenged by Trygon she readily accepted and with stood the test which even Aeetes failed to accept.

Circe evolved into a more complex individual who accepted her flaws and tried to redeem herself from them. She as a young individual rebelled against her father and her rebellion took her to Aiaia. Aiaia saw her transformation into a real witch who was self-sustaining and she even tried to help sailors who knocked at her door. When the men threatened her she wreaked havoc on them. She transformed them into pigs and punished them for their cruelty.

After becoming a strong individual Circe creates her own realm with her willingness to express her own desires and thoughts. In an article titled “I Will Not Be Silenced”: Voice and Autonomy in Madeline Miller’s *Circe*, the author pronounces

Circe’s voice is her strongest tool to proclaim her growing autonomy; she learns to vocalize what she wants, declaring herself free of family ties and narrating her own mythology. . . . She learns her own autonomy by using her voice to declare

her desires rather than embracing the protection offered by silence. Her voice also functions to cast spells and work transformations that allow Circe to break free of the gods' oppression. (Morgan Thomas 2)

Divinity did not safeguard Circe from the cruelty of other gods around her. She was taken for granted in most of the circumstances by her immediate family as well as her kins. Circe was treated with respect only when she hardened herself and became cold hearted. Circe was not destined to be a witch but her banishment had brought about the change in her. She transformed into a much better individual and excelled in her magical arts.

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Sufferings and success story of Rahima: A Critical Study of Nadia Hashimi's The Pearl That Broke its Shell

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ABSTRACT

This paper is entitled "Sufferings and success story of Rahima: A Critical Study of Nadia Hashimi's The Pearl That Broke its Shell" deals with the identity and culture in the novel The Pearl that Broke Its Shell. Culture takes a main part in a patriarchal society to subdue women. The culture of Afghan society is to perceive women only as sexual objects and an object to prop up sons. In this novel, The Pearl that Broke Its Shell, Nadia Hashimi projects two women in Afghanistan living a century apart but tied by legacy. This paper pictures, how the culture and rules of the society affect the identity of women in Afghan society. Their mindset has been altered by society when they are asked to change according to their cultural needs and they prompt to accept it, this affects their identity. In this world, people have their own culture and way of style, however, the voice of Afghani women becomes unheard when raised in a family or society. One of the most awful cultures of Afghani is 'Bacha posh' affects the girl children in the society mentally, it is considered to be a Vanity of human wishes.

Keywords: Culture, A bacha posh, Afghan society, Identity

Culture refers to the customs, practices, language, values, and world views that define social groups such as those based on ethnicity, religion, or common interest. Cultural identity is important for people's sense of self identity and how they relate to others. The identification of women in society changes by the name of cultural needs. The novel *The Pearl that Broke its Shell* mainly focuses on a culture that affects women's identity, it intertwines the life of Shekiba during 1900 and Rahima who lived in the year 2007, two women in Afghanistan society separated by a century, it portrays the expedition of Afghan women in male dominating society and their struggle for their survival. This paper illustrates, how society and culture misused women for their own needs and portrays the powerlessness of women in the particular society, and the costume that made women fall prey to the practice of 'bacha posh'.

Culture subordinate women and treat them mercilessly and plunder their rights. In the patriarchal society, the perspectives and opinions of men are regarded highly and implemented even if it seems socially dumb whereas women are deprived of their basic rights

like the right to voice out, express their desires and show their opinion in familiar matters owing to suppression in male chauvinistic society.

On looking upon this particular text of Nadia Hashimi, *The Pearl that Broke its Shell*, the practice of 'bacha posh' never hides the identity of women rather than gives little privilege to wander out in the streets. This is mentioned in the novel that the families without a boy child follow such practice in order to send their younger ones to run the household chores. In one hand it seems a kind of freedom is given to girl children but on the other hand psychologically it fill them with unhappiness or discontent.

'Bacha posh' again degrades the woman's identity, it is evident from this practice that how the identity of a girl or a woman is considered a curse. While reading the course of the story, one could easily find that the changed identity of Rahima never gives her comfort or power. She is never considered equivalent to a boy. "He doesn't trust me to watch over his women and he has collected a group of women who are kept as men" (Hashimi 114). People could identify her still as a girl who runs chores for a family. The point to be noted that, even though she is allowed to go out of the house, Rahima is not allowed to go out with her own identity, she was not allowed to sway in the street. She must dress up as a boy who carries the blessing that is a guy to do everything. This insistence on holding a guy's identity never fails in showing how is a man respected in an Afghani society.

Rahima, though dresses herself as a boy is restricted to do what actually boys do and the freedom they possess. Her mother knows well that she has to be married to a man to save the dignity of the family. She is even aware that her husband Arif is useless and spends all the money on drinking, never ever questions him or speak a single word against him, because she abides by the law of the patriarchal society and expects the same from her daughters too.

Arif never considers his less care towards the family as a vice. Without considering their daughters age and wish, he married of their daughters to Abdul Khaliq and his brothers simply because to pay his debt. He even gets irritated seeing his house filled with daughters and utters, "If I had a son, this would not be happening Goddamn it! Why do we have a house full of girls, not one, not two, but five of them" (Hashimi 5). Moreover, he feels so happy that he can get his three daughters married at a time and can get an amusing amount of wedding pay from Abdul Khaliq and his brothers. He never cares to ask for the willingness of his kids. He neither seeks their likeness nor foresees their future.

The most pitiful thing is that the three daughters fall into the trap and have no option rather than complaining about their fate to be born as girls and it is noted that they are not old enough to be called women to marry men. Being young and born as women the sisters have

courage to raise voice against their father and all that they could do is console one another and lament among themselves.

Rahima's mother Raisa, though cares for the wellbeing of all her five daughters cannot stop the marriages of her three daughters with almost the age of their father because she lives in the society which respect the men and give little importance to women. Finally she considers herself as a failure in creating a good circumstances for her daughters.

Khala Shaima is the jewel of the novel, she can be considered as the voice of the novelist, Nadia Hashimi. This novel is set in the early 20th and 21st centuries. Though there is a difference of a century, most of the incidents coincide. The plot portrays how society has not improved its standard of thought even after a century. The novelist showcases how there are still places that are not developed in notions when the whole world is considered technologically and scientifically improved. More than the improvement in science and technology, the world believes that human beings are civilized considerably. This novel holds the idea that some parts in the world still carry all the backward thoughts and rituals which are considered to be the proud identity of the particular social community. The people of the community have no questions against the rituals until they are affected directly.

The inclusion of the character Khala Shaima, deliberately explains the practices as vices. Khala Shaima delivers ideas of an actual civilized world that cannot be brutal against a particular community under the name of gender. She strongly believes that education can bring out a difference in the lives of girls, she is a knowledgeable lady who often cuts off the gender-biased words of Arif. Khala Shaima motivates Rahima saying that difference cannot be achieved quickly, there will be humiliation, agony, and hardships on the way to eradicate the old principles from the society.

The author depicts the protagonist's struggle in the book and shows how to get out of difficult situations. The book's title is appropriate since it tells the story of a girl who struggles to define herself in the face of adversity while trying to get out of her shell. Rahima is treated like a pearl throughout the story, which is symbolized by the phrase "The Pearl That Broke It Shell." She struggled greatly from an early age and didn't want to live a wretched life like other Afghan women. She was on a mission to experience her independence as an Afghan male. She consequently made the decision to emerge from her protective shell in an effort to move into her ideal life and get away from her current issues. Later on in the book, she also comes to the realization that she cannot be taken for granted because she is as priceless as a pearl.

As mentioned in the article by Jibin Monish V & Dr M. Kannadhasan titled, “The Struggle of Women against Oppression – A Study of Nadia Hashimi’s *The Pearl That Broke Its Shell*”:

The bravery of Rahima inspires others to resist persecution. She finds a safer haven by fleeing to a shelter. She is free to live her own life without being oppressed. She is saved from male dominance since she can do it independently of her husband. In the end, she will be able to free herself from men’s dominance. When she is at the shelter, she discovers that anyone can save her life from oppression by getting an education. She understands that education can be a weapon in her fight against the patriarchal society that oppresses her. (1214)

The plights deserved by the women characters in the novel are to a great extent but the novel ends with a positive note of Rahima. Thus, the novelist shows off a new ray of hope to the women in the world.

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Significance of Women and War in Kate Quinn's *The Alice Network*

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ABSTRACT

The paper "Significance of Women and War in Kate Quinn's The Alice Network" deals with the role played by the network of women spies during World War I and II known as 'Alice Network'. Women are often compared to flowers to stress the point of femininity. In The Alice Network, Kate Quinn compares women to flowers of evil which is also a work of a French poet, Charles Baudelaire who is an idol for the antagonist of the novel, René Bordelon. This paper showcases the struggles of warrior women, the horrors of war, the identity crisis caused by war and many more. War is the major theme of the novel and this paper is to throw light on the struggles of the four central female characters, Evelyn Gardiner, Louise de Bettignies, Leonie van Houtte and Charlotte St. Claire.

Keywords: Spy, Alice Network, *Les Fleurs du mal*, Women and War

The Alice Network is based on the real-life World War I spy ring called the 'Alice Network' which operated in German-occupied France and Belgium. There are three historical figures used as characters in *The Alice Network*. They are, Louise de Bettignies, the leader of the ring whose code name is Alice Dubois, also called Lili in the book. Leonie van Houtte, Lieutenant of Louise de Bettignies, code name Charlotte Lameron and Cecil Aylmer Cameron, a British 3 Intelligence officer who is called as Captain Cameron and Uncle Edward who recruited both the women in real life and in the novel. By the theory of Deconstruction, Quinn breaks the societal norm of women being suppressed and she gives a break through by making all of her female characters empowered and shows the readers how strong, brave, fast and smart a woman can be. The novel uses a dual narrative approach, alternating between events that occurred beginning in 1915 and 1947.

Les Fleurs du Mal is a controversial work written by the French poet, Charles Baudelaire. Most of his works portray images of love and the erotic, which for him involves evil. His work primarily focuses on women. His female characters were usually erotic and had sadistic imagery. Baudelaire believed that beauty could evolve on its own, irrespective of its nature and even fueled by sin. He had a clear opposition between two worlds: 'spleen' and 'ideal'. Spleen signifies everything that is 'wrong' in the world, like death, murder, solitude, etc. The ideal represents superiority over the harsh reality of spleen. The ideal is merely an

escape from reality through wine, opium, travel, passion, etc. He often uses erotic imagery to transmit the impassioned feeling of the ideal. The speaker of his works is endlessly confronted with the fear of death, the failure of his will, and the suffocation of his spirit. Here, in *The Alice Network*, all these descriptions can be completely related to René Bordelon, the antagonist of this work, who is also a devoted fan of the works of Charles Baudelaire.

Women are Baudelaire's main source of symbolism. They often serve as a bridge between ideal and spleen. The speaker's lover is both his muse, providing ephemeral perfection, and a curse. The same way René considers Eve his muse and a lover, eventually finding his end in her. Women embody both what Baudelaire called 'the elevation towards God' and what he referred to as 'the gradual descent towards Satan'. René is someone who is not perfect but pretends to be perfect. He is someone who wants everyone to be afraid of him and to respect him. He wants himself to be a 'know it all' person, and he doesn't like people keeping secrets from him. He is a character who has all the qualities of the speaker in Baudelaire's works, and he is also a person who loves the works of Baudelaire and praises him every chance he gets. Eve was named 'fleur du mal (flower of evil)' by René because he loved *Les Fleurs du Mal*, a work of Baudelaire. "There were lilies in a slender fluted vase on the mantel, long-stemmed and graceful. Evil-eyed lilies, fleurs du mal, kept forever in glass." (366)

Women are often described as sensitive, closer to nature, emotional, and dependent. "We are not flowers to be plucked and shielded. We are flowers who flourish in evil." (228) Likewise, flowers are often symbolized as something feminine. But what many people fail to understand is that flowers adapt themselves to all the climatic situations just like women do with situations. Throughout history, women participate in all forms of activities and one among them is war. In *The Alice Network*, women play a great role in both the World Wars as a spy, captain, soldier, etc. In the then patriarchal society, women are not given any importance and they are often not taken as a threat. In *The Alice Network* the central characters, Eve, Lili, and Violette act as spies in the German occupied France and gets information that are used against the Germans. Charlie St. Claire another central character who goes on a search for her lost cousin and fights her own war with the German profiteer who is behind most of the assassination that happen in France by the Germans.

"He started giving flower names to the rest of his 'nieces' like Violette—you'll meet her soon; she'll hate you, but she hates everybody—and now you: Marguerite, the little daisy. We're his garden, and he fusses over us like an old maid with a watering can." (79, 80) Here,

Quinn is clever to compare each character to a flower and gives them the name of a flower, which can also be interpreted in a way where the story completely focuses on Baudelaire's *Les Fleurs du Mal*. The code name of Louise de Bettignes is Alice Dubois which she later changes to Lili. Lilies are often described as flowers symbolizing love, purity, and positivity. In Lili's case, she is someone who is positive in all situations, someone who is pure, brave, and courageous, and someone who is capable of love. She was also a lily of the valley, one that is poisonous and can cause death. Even with all these qualities, she is also someone who is dark and someone who wouldn't think twice before striking, if someone meant harm to any of her fellow mates. When Eve, Violette and Lili were put in the Siegburg prison in Germany, Lili serves as a ray of light and hope and always has a positive attitude, just as lilies represent purity, positivity, innocence, rebirth, and hope.

Violette Lameron is the code name of Leonie Van Houtte. Violette is someone who hides her love with a cold mask, just like the violets. Violets are flowers that symbolize modesty, faith, everlasting love, innocence, and remembrance. All these qualities can be seen in Violette too. She is modest, her loyalty and love for Lili are unshakable, and she is one of the characters who live with the memoirs of Lili.

A person who spy needs to keep her emotions and face composed. One must be well composed, witty, brave and clever to get away from dangers. Evelyn Gardiner is just like Evelyn Rose, which symbolizes a freedom-loving, free-spirited individual. She goes to spy in a German occupied France and works alongside the 'Queen of Spies', Lili and her lieutenant, Violette Lameron. As events unfold, Eve works for a German profiteer, René Bordelon and gets information from him by bedding him. She passes the information to the head of the ring, Lili and stay as a useful informant for her country. When feelings get involved and things turn around, Violette is imprisoned, Lili gets captured and Eve gets caught in a mess with René Bordelon and eventually leads Eve to believe her as a betrayer. Lili dies in the prison, Violette calls her 'Judas' and Eve becomes an alcoholic.

Thirty years later, a young American Charlie St. Claire sets on a journey to find her lost cousin after World War II and seeks the help of Eve. As the story proceeds, Charlie gets to know about her cousin's death along with her daughter and learns the reason behind her death is René Bordelon. She seeks revenge for Eve, who was also wronged by him in the past. Charlie comes as a ray of light and hope in Eve's life, healing her traumatic experience of being a spy during the war.

Charlie is a character who is psychologically affected after living through the war and her brother's suicide. "The first person I met in England was a hallucination." (3) Her

cousins' absence also take a toll on her. "Opium isn't a truth drug, Eve! It makes you hallucinate, but that doesn't mean it made you talk!" (477) Hallucinations of Eve happened only because of the opium in her. Though it was the opium doing its work, Eve has had trouble sleeping, wakes up screaming, and shoots everything with her Luger. Even with these psychological imperfections, women played a great role in each situation and made themselves flowers of evil.

The novel is based on the real-life incidents of two spies named Louise de Bettignies, code name Alice Dubois, the queen of spies, and Leonie van Houtte, code name Charlotte Lameron (Changed into VioletteLameron). They were the great historical figures during the World War and are little known today. All the spy works in this novel are true happenings in the lives of these women spies. Evelyn Gardiner is a fictional character meant for the plot of this book. Louise de Bettignies was a charming and notable spy during the war who took risks every day, as mentioned in this book. Most of the incidents included in the plot are true incidents, and Louise de Bettignies's luck did run out when she exchanged a pass with a naïve lady named Marguerite, and Louise incensed the German officials by eating the coded message and then asking for a brandy. "Lili. So, Eve had Lili, and I had Rose. All these flowers. There are two kinds of flowers when it comes to women, Eve said. The kind that sit safe in a beautiful vase, or the kind that survive in any conditions...even in evil. Lili was the latter. Which are you?" (336)

Women still play a great role during wars. They are much more welcomed in today's world whereas in the olden days, it was not very much appreciated. Though women spying, being a soldier and captain is normalized, the struggles remain the same even today and they increase day by day. The women shown in *The Alice Network* play a very great role in the success of war and women in general fight their own battles not only in the battlefield but also in their day-to-day life.

Kate Quinn's *The Alice Network* focus on the role of women as the silent warriors during war. It also discusses the aftermath of war, its impact on one's life and society, the cultural changes after war and how people cope up with the after effects of war. When a literary work or a movie is produced based on war, the author or the writer focus on the importance of world peace and emphasize on ending future wars. Its horrors and effects are shown and they also showcase the life of the soldiers who fight for their independence; their sufferings, challenges, and achievements. In *The Alice Network*, Kate Quinn focus on bringing back two historical figures who worked as spies in the German occupied France during World War I. Her main focus is to turn people's attention back to history and give the

readers a view on the 'Queen of Spies', a real-life female spy, Louise de Bettignes along with her network of spies who contributed a lot by passing valuable information during World War I.

During World War, women played a vital role in the war effort, both at home and in a variety of roles that directly supported the military. During this time, their responsibilities changed and broadened, challenging the notions of gender and laying the foundation for future advancements in gender equality. Women took into roles normally filled by men who were serving in the military during the war. Women produced necessary military items including ammunition, weapons, clothing, and supplies, by toiling at factories, munitions plants, and other industrial settings. On the front line, women worked as nurses, ambulance drivers, and medical assistance. While some followed these notions, there are notable women warriors throughout history who directly or indirectly contributed during World war. Some participated in war as soldiers whereas some worked as spies.

Women have been fighters throughout history. Yet, how they are viewed and accepted in combat roles vary throughout cultures and eras. From the old age, Joan of Arc, also known as the Maid of Orleans, was a medieval French military leader. She played a crucial role in the French victories at Orleans and Patay. From the middle age, Hannah Snell, a British woman who disguised herself as a man, served as a soldier and marine in Royal Marines during the 18th century. Even at present, during the war between Ukraine and Russia, more than 60,000 Ukrainian women volunteered to serve in the Ukrainian military defending Russia's aggression. In The Alice Network, the central characters like Lili, Eve and Violette served the English and spied the German occupied France. They too acted as women warriors who are hidden in the history.

The hardships of war heroines are frequently explored and emphasized by authors because it draws attention to the harsh realities and sacrifices those women, as well as other people, go through during times of battle. By illustrating the agony and difficulties that war heroines face, authors and viewers can better understand the psychological and emotional toll that war has on its victims. Showcasing their suffering brings to light the difficulties experienced by women in conflict, highlighting gender inequalities, discrimination, and the overall effects of war on civilians. It arouses the empathy and compassion in readers and encourage them to consider the human cost of battle and take action to bring peace. Many authors also emphasize the successes, resiliency, strength, and accomplishments of military heroines. These tales frequently highlight their courage, determination, leadership, and

contributions to overcoming hardship. The challenges and victories of individuals can be highlighted in literature and all forms of media too.

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Exploring the Narrative Techniques in Paulo Coelho's The Devil and Miss Prym

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ABSTRACT

The research paper titled "Exploring the Narrative Techniques in Paulo Coelho's The Devil and Miss Prym" analyses the narrative techniques employed by Paulo Coelho to bring out human nature. Narrative techniques highlight the author's expertise in storytelling with ample focus on the explication of the themes and motifs. The narration gives an enriching experience taking the readers towards exploring the strategies and techniques and, the understanding of the narrative. He uses setting of the story, timeline, flashbacks and foreshadowing, third-person narrative techniques, repetition, character development, building the story on conflicts, giving importance to both protagonist and antagonist, audience surrogate, author surrogate, allegory, thematic patterning, and above all linear narration to make the rendition interesting.

Keywords: Narrative Technique, Narrative Structure, Styles

Narrative technique is the way in which a writer conveys what he wants to say to the readers. It is a method used to develop a story. This technique falls into six categories: character, point of view, plot, style, setting, and theme. All these play an important role in developing the story. This helps the audience receive the writers' message in a deliberate way. Narrative structure is the blueprint of the novel and narrative techniques are its building blocks. There are four types of narrative structure. The most common type is 'linear' otherwise known as 'Freytag's Pyramid'.

Freytag's Pyramid is created by Gustav Freytag (1816-1895), a novelist and playwright. His literary fame was made universal by the publication of his novel, *Soll und Haben* (Debit and Credit) in 1855. It was translated into all European languages and it was translated into English by Georgiana Harcourt in 1857. Freytag developed this narrative Pyramid in the 19th century. Many fictional writers had used it for centuries as a description of a structure. In this type of narrative the story moves from beginning to end in chronological order. Freytag's Pyramid follows a pattern of five acts. They are 1) beginning or character introduction, 2) problem or conflict, 3) plot climax, 4) resolution, and 5) end or character conclusion.

Paulo Coelho is often considered a modern writer, and his works are generally classified as contemporary literature. His themes often reflect the concerns and issues of the contemporary world. When reading his novel, one immediately notices his simple style of writing. He imparts insightful lessons through the conversations of his characters and through his straightforward prose. He addresses life's complex questions with a clear and deeply touching approach. He writes directly from his heart considering every perspective of human ideology in his writing. His philosophical points are straightforward without complicating the topics. His storytelling style is evident in every novel, allowing readers to follow the uncomplicated plots while absorbing the philosophy.

Coelho's writings convey messages through direct, concise sentences, honest dialogues, and minimalist descriptions. He often repeats sentence structures to emphasize the actions of his characters. The use of the past tense in his narratives gives the impression that he is a master storyteller. His novels are not rich in descriptive or flowery language. The themes and subject matter take precedence over detailed settings or appearances of his characters. However, attention to detail in key moments adds depth to the central plot.

Coelho's writing style is challenging to define. It is poetic, philosophical, deliberate and conversational. His straightforwardness, at times, enhances the intensity of his messages without being harsh. He uniquely combines frankness with profound philosophical storytelling. Many consider Coelho's lyrical writing style to be a universal language. His simplicity and poetic flow allow readers to easily connect with the development of his characters and the unfolding of events in his story. He stands out not only for his subject matter but also for his direct and uncomplicated delivery.

Coelho effectively employs the setting as a narrative technique in *The Devil and Miss Prym* to create a rich and symbolic backdrop for the story. The setting is both the time and the geographical location within the narrative or within a work of fiction. Coelho's setting is a small fictional town called Viscos. This isolated town is located in a remote mountainous region. The setting is described in the novel as a tranquil and picturesque place, surrounded by mountains, forests and natural beauty.

Paulo Coelho also uses flashback technique. Flashbacks and flash-forwards are narrative techniques that transport readers from the chronological present of a story to events that occurred in the past or future, which have a direct impact on the characters in the current timeline of the narrative. These shifts in time offer readers valuable insights into the backgrounds of characters, their motivations, and how the past or future events influence their

actions and decisions in the present-day narrative. This technique adds depth and complexity to the storytelling, enriching the reader's understanding of the characters and the overall plot.

‘Once, many years ago, a hermit - who later came to be known as St Savin - lived in one of the caves hereabouts. At the time, Viscos was little more than a frontier post, populated by bandits fleeing from justice, by smugglers and prostitutes, by confidence tricksters in search of accomplices, even by murderers resting between murders. The wickedest of them all, an Arab called Ahab, controlled the whole village and the surrounding area, imposing extortionate taxes on the local farmers who still insisted on maintaining a dignified way of life. (24)

The flashbacks help to reveal the personal backgrounds, struggles, and key events that have shaped the people of the town and their responses to the moral challenge presented in the story. This narrative technique adds depth to the characters and enriches the investigation of human nature, morality and the eternal struggle between good and evil.

Coelho also uses foreshadowing which is a narrative technique that drops fine hints about upcoming events within a story. This allows audiences to anticipate and guess the upcoming events, adding an element of pressure and emotional engagement to the narrative. It becomes a literary tool that keeps audience turning pages to see if their predictions come to fruition. It's often used to create a sense of pressure or mystery, especially in suspenseful or mysterious stories. Authors do this to make the story more interesting and to keep readers engaged.

Berta, however, had a reason for being there. And that morning her waiting came to an end when she saw the stranger climbing the steep hill up to the village, heading for its one hotel. He did not look as she had so often imagined he would: his clothes were shabby, he wore his hair unfashionably long, he was unshaven.

And he was accompanied by the Devil. (1)

Coelho also uses third person narration as it has a neutral narrator, which is not personal to the thoughts or feelings of the characters. It allows the author to limit the perspective of the audience and to control the information that they get to know. It is used to build interest and to heighten the suspense. It allows the writer to act as an omniscient narrator. The information about every character and situation is given to the audience, allowing them to get a further chance to develop empathy. In this way the audience is allowed to learn more about the world outside of the confines of a first-person perspective.

Concerned about the future, or, rather, about the fact that Miss Prym's story might spread and drive away hunters and tourists alike, he decided to call an

emergency meeting. The group were gathering in the sacristy of the small church, just as Chantal was heading for the forest, the stranger was off on one of his mysterious walks and Berta was chatting with her husband about whether or not to try and save the village. (104)

These lines demonstrate the third-person narrative perspective, where the narrator describes the thoughts, feeling and actions of the characters from an external point of view. This perspective is commonly used throughout the novel to provide insights into the characters and in the unfolding events in the story.

Coelho uses allegory in which truths or universal lessons about human behaviour or experiences are presented through symbolic fictional characters and events. In other words, it is a way to tell a deeper, meaningful story by representing real-life concepts or ideas through imaginative and figurative elements. The stranger, who arrives in the town symbolically representing the Devil, serves as an allegorical character. The interactions and dialogues between the stranger and the people of the town are rich in allegorical content, as they explore the themes of morality, human nature, and the eternal struggle between good and evil in a symbolic and metaphorical manner.

‘That’s normal, it always happens at this time of year,’ she thought. It was simply a coincidence and had nothing to do with the stranger’s arrival.

Then, in the distance, she heard a clap of thunder, followed by another three. On the one hand, this simply meant that rain was on the way; on the other, if the old superstitions of the village were to be believed, the sound could be interpreted as the voice of an angry God, protesting that mankind had grown indifferent to His presence. (3)

These lines illustrate the allegorical nature of the stranger’s character and the symbolic role he plays in the novel, representing broader themes and questions about morality, human nature, and the eternal struggle between good and evil.

Coelho uses thematic patterning which involves spreading recurring themes and moral motifs across different elements and parts of a story. In a well-crafted narrative, this patterning can highlight the central message or significant idea that ties together various events and elements in the story, emphasizing their commonality or shared meaning.

‘Who am I? Well, let’s say I’m a man who, for some time now, has been searching for a particular truth. I finally discovered the theory, but I’ve never put it into practice.’

“What sort of truth?”

‘About the nature of human beings. I discovered that confronted by temptation, we will always fall. Given the right circumstances, every human being on this earth would be willing to commit evil.’ (14)

The exploration of moral dilemmas, human nature, the struggle between good and evil, and the consequences of individual choices are explicated by employing different techniques.

Coelho brings out complicated philosophical points and moral dilemmas through simple narrative techniques. His thought-provoking dialogues and character interactions delve into complex questions about human nature, morality, and the eternal struggle between good and evil. Readers have praised his talent for crafting characters that are relatable and multi-dimensional. The character of Chantal is relatable because they have significant problems like moral dilemmas and true nature of humankind. He has used setting of the story, timeline, flashbacks and foreshadowing, third-person narrative techniques, repetition, character development, building the story on conflicts, giving importance to both protagonist and antagonist, audience surrogate, author surrogate, allegory, imagery, satire, paradox, thematic patterning, and so on which in turn makes the plot of the story very interesting with its linear narration.

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Dark Humour and Meta Irony: A Stylistic Reading of Jeremy Robert Johnson's The Loop

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ABSTRACT

Hope amidst crisis is a crucial need for the Gen Zs who are called the digital natives. Various factors like culture, society, race and gender influence this young group of people to transcend from postmodernism to metamodernism. In the metamodern world, the emotions of people oscillate between positive and negative feelings. It is presumably the Gen Zs' euphemistic way of maintaining a positive attitude in a life of crisis. They use dark humour and meta irony in order to escape from their real life. In light of Jeremy Robert Johnson's The Loop, this research paper explores the narrative style in order to bring out the relevance of bizzarro fiction with the Metamodern lifestyle of the Gen Zs. This paper also tries to prove that bizzarro, a sub-genre of science fiction, can mirror reality effectively. In addition to this, it also delves deep into the beliefs of the Gen Zs and their perspective of life which oscillates between their nostalgic past and a dreadful present with a hope for a better future.

Keywords: Bizarro, Dark humour, Gen Zs, Meta irony, Metamodernism.

The emerging cultural trends and the invasion of artificial intelligence have made drastic changes in people's perception of life. Metamodernism comes in as a rescue and as a distraction for the young folks of this era. The term is coined by Mas'udZavarzadeh. It is intended to fill the gap between the very extreme bipolarities in human emotions and beliefs. That is, it oscillates between humour and sincerity, irony and honesty, optimism and pessimism and fluctuates between such contrasting facets of life.

Metamodernism makes people independent of sustaining in the illusory postmodernism and the objective modernism. It is mostly associated with the age of the Internet. In the predominant usage of the internet, people showcase their talents using creativity. They unite via the internet to share positivity. In the article titled "An Introduction to Metamodernism: The Cultural Philosophy of the Digital Age" Anne-Laure Le Cunff, a neuroscience investigator says, "While most of the Internet population is passive, metamodernism is not to be confused with pseudo-modernism . . . Instead, metamodernism is about genuine connection, empathy and community". The evolving concept of Metamodernism prompts self-analysis and evaluation.

Metamodernism is almost practiced everyday by the Gen Zs, as they have an intimate connection with the internet. Their recent addiction in absurd jokes and weird animations may seem humorous to the extreme but has a deep meaning. Dark comedy or black humour is a comic element used in literature in order to counterpoise gloominess with fun. The term “black humour” (Sinha 3685) was coined by the Surrealist, Andre Breton in 1935. This is usually employed by writers to convey messages which are not usually accepted by the public in general.

The Gen Zs express their contempt for social anxiety through the medium of internet. VarshaKusnur in the article titled, “An Analysis of Gen -Z Humour: One Big Inside Joke” avers:

However, this absurdity could cross the line and quickly morph into dark humour or nihilism. . . Gen Z has not lost hope in creating social change yet. Dark humour is a sign that we acknowledge and are aware of social issues and believe that the current tragic state is not the end state, allowing us to be light hearted about it. Humour is and has always been our means of coping with the stress and anxieties of the world, helping us feel understood and be a part of a larger community to share our laughter with. Whether it be colourful minion memes or a chaotic composition of random videos, it has always been our independent tool of expression.

Johnson became more famous with his publication of *The Loop* in 2021. The work is a thriller fiction centered in Turner Falls, a small town in Oregon. The two protagonists Lucy and Bucket are portrayed as people distanced from their peers who have a different definition for their culture. Among them, Lucy is predominantly portrayed as the main female protagonist from whose lens the reader can actually realize what happens in the plot. She does not want to embrace her culture as she has a traumatic past experience in Peru. She finds likeness with Bucket as both are termed as “exotic” (Johnson 11) in their school because of their colour. Both of them are oppressed as they cannot be found as equals to their elite and white classmates and even the towns people.

Lucy gets a new friend named Brewer. Along with Bucket, Brewer takes Lucy to the drink party managed by the popular high society kids from the place called Brower Butte. The bon fire party is held in East Bear Caves where an unexpected homicide attack happens where these high school folks start to experience a violent rage and kill one another. It is only later the real reason for the outbreak could be found.

Meanwhile, the town also becomes victim to the power politics played by the IMTECH, a bio-tech company, which makes people as victims to some infection which

makes people murder one another. The oracle's infectious device combines with human biology. It dwells and replicates under the skull of the affected ones. The device has tentacles like animals called hectocotylus which helps it to cling to human tissues and can replicate like cells.

There is a broadcast given continuously in televisions which releases signals and whoever views it or even hears it can get an imbalance in mind which will deprive them of energy unless they keep on killing others. The broadcast informs:

message from the emergency broadcast system... potential leak in the storage of underground toxic waste at the now-defunct Handsome valley Nuclear Power Plant. A low-level earthquake, barely detect...may have caused a fracture in the twenty-foot-thick concrete surround...Travelers... turned back for a thirty-mile radius around the Turner Falls area.... Effects include confusion, hallucination, paranoia and... (112)

In between, the book gives hints of the epidemic through a podcast called "Nightwatchman" (Johnson 3). The dark comedy is outlined by the author as he shows the classmates and other peers of Lucy who enjoy the Bohemian way of drinking and having merry despite the truth that children of their own age are being killed. The young children in their high school age, depicted in this fiction, are victims to drugs and never feel guilty for promoting obscenity in their words and deeds.

The protagonist Lucy can be found as a representative of this target group – the Gen-Z. She suspends the fear of the outbreak as she thinks that taking that fear to mind can make her even more depressed. She does not want to discuss about the missing of her classmate Jason Ward with Bucket and even Bucket does the same believing that this act of delaying can save his mind from being excessively hurt. Lucy, who is still a growing child has to act like she is happy to her parents in order to avoid their agony for her.

Altogether it is the escapism which Lucy maintains in order to check the impact of the bizarre world around her. Lucy, as a protagonist, differs from others for her presence of mind and confidence. She uses self-affirmation to move on in spite of all the wreckage and terror. Sebastian Dravyam Pillai in, *Post- Modernism: An Introduction to Post-War Literature in English* declares

The typical Post-Modern hero is hopelessly sick and is unsure if he has a self of his own to speak about... Consequently a good number of Post-Modern protagonists give a strong impression of being mere role players. They are more often than not formless performers and cardboard cut-outs with no Forsterian soundness

about them. Each has patterned his or herself on this or that celluloid hero or comic book zombie or cowboy. (68)

The Loop, in some way, can be perceived as an alarm for what might happen if human beings actually lose humanity. The author emphasizes this through his words saying that, “All of them acting like everything was great in the midst of everything wrong” (Johnson 81). This will in turn lead to an unacceptable dystopian struggle. The narrative style portrays excessive obscenity and unpleasant conversations which are not expected from youngsters belonging to high school. The current scenario shows the responsibility enforced upon the younger generation irrespective of their younger age. The depression and the hectic lifestyle they live is too much for their age.

Lucy asks questions which makes her an unreliable and unpredictable user of such irony. It is impossible to differentiate whether she feels bad for the situation she exists in, or she just comments for fun. She says, “What happened that day? What did I see?” (35). Meta-irony does not agree with portraying itself as ironical and at the same time does not reveal any truth about the feeling of the one who represents it. This irony makes the readers oscillate between being cynical and being sincere.

Lucy’s alarm sounded from the dresser across the room, waking her for another day of playing pretend. ‘Yes, I’m fine today.’ ‘No, I didn’t have any nightmares.’ ‘Yes, I care whether or not there are fresh blueberries at breakfast. The simple pleasures are important! . . . Because that would mean that something is broken inside of me, right? And I’m doing great!’ . . . ‘No, I haven’t had any suicidal or self-destructive thoughts. Trust me, I’m going to be okay.’ We are all going to be okay. (22)

The speaker in the Nightwatchman podcast discusses the totalitarian mindset of the government effortlessly in his own style. He discusses an unagreeable news of insecurity about a new app which is actually a security breach system. He says, “Thanks to the undeletable MoonLitetrashware app installed on most every device regardless of manufacturer” (3). The podcast which turns up at 03:47 a.m. has a large group of audience who really like to watch it for updating themselves “in the ever-stormier sea of lies” (3). The podcast is probably added at the beginning to loosen up the tensed mindset of the readers. It is also an element of foreshadowing which alerts them of the incidents which can happen later. The speaker in Nightwatchmanpodcast, feels it is very casual to reveal such a statement ironically. He further hints but not reveals about the totalitarian government saying, “maybe

you think, they'd never track me. They'd never listen to me. And to that I say... Yeah, right" (4).

The murder-suicide happening at the beginning of the novel is expressed as, "Next up we've got grimmer fare: a murder suicide" (4). He ironically comments on the involvement of corporates in plundering the resources of the people of Turner Falls. When he further says, "It sounds nice, doesn't it, folks?" it does not actually sound nice but is rather a hidden critique of the power politics. This is a complete 'ironesty' (Dember) depicted in the novel.

Ironesty is a term coined by Gred Dember, which is a combination of irony and honesty. The podcast, to a certain extent, alleviates the chaotic situation and gives an ironically hopeful situation. It states, "Good Morning, Turner Falls! Murder squads, military blockades, and mind-pulverizing audio transmissions got you feeling like you woke up on the wrong side of bed? Head downtown to try one of our newest offerings: suicide by cop! But maybe we don't have to die..." (167). Irony is further used to scathe the power politics used by people in supremacy to threaten people with their military and various alarming policies. The novel uses irony to show that the Turner Falls Police Department does not do proper investigation of the homicide cases. This situation is accurately captured in Jay Leno's monologue joke where he said, "So if you need to murder somebody, maybe head on over to Turner Falls, Oregon" (167).

The cultural theorists, Timotheus Vermeulen and Robin van den Akker, in "Notes on Metamodernism" opine:

One should be careful, however, not to confuse this oscillating tension (a both-neither) with some kind of postmodern in-between (a neither-nor). Indeed, both meta modernism and the postmodern turn to pluralism, irony, and deconstruction in order to counter a modernist fanaticism. However, in meta modernism this pluralism and irony are utilized to counter the modern aspiration, while in postmodernism they are employed to cancel it out. That is to say, metamodern irony is intrinsically bound to desire, whereas postmodern irony is inherently tied to apathy. (9-10)

The Gen Zs displace trauma ironically with sarcasm. Since they grow up with social media, they use it as a tool to express their ironic mindset. Their preference for newness motivates them to be seen as the variants that they should not be brushed aside as normal or ordinary. They do not try to break or deconstruct hierarchy as postmodernists do but reconstruct things to build a better society to live in. Oliver Sotirios Bourne in "Understanding Gen -Z: Post-ironic Humour" asserts:

The Post/ Meta-ironic is evolution, it is a coded reality for younger generations to camouflage in a time where they are more visible than ever. Gen Z are born with social media; a categorical documentation of their entire lives. Older generations had the privilege of finding themselves and establishing an identity before proclaiming it to the world whereas Gen Z did not. This complex webbing of irony allows them to morph and change whilst under observation, allowing them to push the boundaries of thought in a time where the scrutiny of public opinion weighs heavy in a cancel culture.

Meta modernism assures to create a positive environment among societies. It is a kind of ripple effect which keeps on spreading positivity and which in turn moves in larger circles. The Gen-Z are constrained to take up the responsibility of handling their situations without anyone's help.

The pain faced by them in reality is expressed as "Bucket thought for a moment. 'It can't, right? My mom always says, "The only constant in life is change" When I was little that made me feel scared. But now...things have got to change, right? Because if it feels like this forever..." (36). Lucy reiterates "it again in the best Brewer voice she could. 'Here we go. Party time, y'all.' The sound of it broke her heart a little time around, but then Brewer said, 'Holy shit, Lucy,' and they both laughed, and it was good to have something that was theirs, if only for a moment" (295).

The narration then moves from the least possible hope to a hopeless situation where Lucy's thoughts say, "Time to realize this plan is madness, the last sad ravings of a man who wanted to believe he could redeem his unredeemable acts... Time to give up this hero bullshit and grab whatever time we have left just be Brewer and Lucy before it's all over" (296). D.C. Muecke in the work *Irony and the Ironic*, says, "This kind of irony where the false image a character has formed of himself clashes with the image that the work enables the reader to form is common in novels" (87).

The weirdness in things help redeem them from the hectic life they live because the world they live in is in an uncontrollable state making them enjoy such things. They start valuing imperfections. The protagonist Lucy and her surviving friends say that they are in a state where, "we shouldn't have to bear this weight. But it's ours, and there's no one else to carry it" (294). In the adversity of life, as Lucy thinks, "He needs these lies, the hope" (294). The Gen Zs as a group collectively perform this and try to act weird.

The oscillation in the narration continues till the end of the novel. Lucy's thoughts go to such an extent that after the oracle gets over, there will be no more kindness. "She thought

of a new world, where no one would ever feel what she'd felt in Brewer's arms, the human animal stripped of whatever kindness it might experience, cultivated only for its ability to suffer the whims of something cruel beyond comprehension" (302). Pessimism is almost rooted completely in Lucy's mind and she completely loses the last hope she had in her. This is just the same way Gen Zs think over what their world may turn into, if there are series of wars and disruptions around them. Metamodernism makes them attain self-actualization of their existence. They realize that anything which causes them problem and suffering can be tackled with their own mind. They gain an insurmountable confidence by themselves. The novel's last lines echo this hope for a better future.

The Loop, in some way, can be perceived as an alarm for what might happen if human beings actually lose humanity. Science fiction as a genre is more often used by authors as an act of foreshadowing the reality in life. The dark humor encapsulated in this form of expression can promote the way of making fun at serious matters which could not be normally acceptable. It is rather showcasing the depression faced by the Gen Zs.

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Quest for Companionship in Dogs: A Psychological Analysis of Stephen Foster's Walking Ollie

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ABSTRACT

Psychology is the study of mind and behaviour in human beings and non-human beings. Walking Ollie is a memoir that deals with a lurcher pup which is adopted by Stephen Foster. This is a memoir where Foster gives a detailed description of Ollie, about how he adopted Ollie and wins its love. When people want to satisfy their loneliness, most of them prefer dogs as their companion. This research study reveals how people are oriented with dogs. People use the pronouns 'he' and 'she' to describe other people. But people have also started to represent animals with pronouns. When people give importance to dogs, they schedule their own time to take care of it. When they try to preserve dogs from danger, they take care of it. This study examines the psychology of people in owning a dog as well as, it deals with the needs of people to have a dog for intimacy. It is to analyse the importance of raising pets which give extraordinary companionship in this bizarre world. Also, it centers on the psychology of human beings and how they make dogs as their companion to overcome grief.

Keywords: Psychology, Behaviour, Companionship, Classical Conditioning

The term 'psychology' is derived from the Greek word 'Psyche' that deals with personality, unconscious mind, motivation, development psychology, and genes and environment. During nineteenth century, Wilhelm Wundt and William James have been considered as the founders of psychology. This research paper deals with the mind and behaviour of Foster and Ollie, how they both have developed a bond between them and also the struggles that are faced by Foster in owning Ollie. It also showcases how Ollie overcomes its fear.

To represent animals and non-living things, people use the word 'it'. But when people get attached with non-living things or animals, they consider it as a human being. In *Walking Ollie*, people use pronouns to refer to dogs. As the dog owners are closely attached with their dogs and so dogs are addressed with the pronouns such as he and she. The Whippet owner says, "my dog is a Whippet, because she is fast – or what?" (12). Here, it is visible that though the Whippet owner mentions her dog by the word dog, immediately she changes the word and uses the pronoun 'she' instead of using 'it'. Rather than using pronouns, pet owners

also refer to their pet as ‘boy’ or ‘girl’. This can be seen when Foster says about the Vizslas. “After we had made friends with ‘the girls’ (we were given treats to feed to them), we all went out for a walk in nearby woods, a walk which lasted for a good hour and a half” (39). This makes a point that, Foster sees dogs as human beings and he has also not brought out any differences between dogs and people in any aspect.

When Foster and Shay, a driver get involved in a conversation, Foster is bored of his humour sense. But when Shay changes his topic to dogs, Foster makes himself as an energetic one. This can be seen when Foster says, “the talk about the horses was brief and bitter but it led on to a conversation about dogs. This was happier territory. Shay told me that he was a lurcher breeder” (21). It is showcased that when people have no interest on certain things, they do not want to have a vast knowledge on that specific thing. This can be seen with the conversation of Shay and Foster. As a dog owner, Foster is only interested with the topics on dogs.

Ivan Petrovich Pavlov’s ‘Classical Conditioning’ tends to show the learning process by experimenting it with dogs. The dog that is used for this experiment, is conditioned with the food and a bell. At first, when the dog hears the bell sound, it does not respond but after conducting this for so many times, it starts salivating when it hears the bell sound. The dog that underwent this experiment is conditioned by knowing that when the bell sound is rung then it will be provided with food. Likewise, in the memoir, when Ollie does not obey Foster’s instructions, a psychiatrist named Attila is appointed by him to make it listen to his words. As experimented by Pavlov, Attila has also stated Foster to use a clicker in training Ollie. “Attila had a little clicker in his hand which he said could be helpful: click it every time he gets the food, and this he will come to understand as a signal of a good thing. Click, food, click, food” (114).

Attila suggests Foster to conduct a like using hiding food, and throwing when he feeds it to Ollie. This shows how food plays a primary role in motivating dogs. Though the three-time meal concept is for people, when dogs become a part of people’s life, they are introduced with three meals per day. Likewise, when a dog is introduced with new things, and when it is made to practise it, then it easily gets adapted to the new culture that are imposed. Dogs identify and protect its owner from strangers when food is prioritised. Somehow, Foster comes to know about this trick and he makes it a practice with Mingo. “This is because you are holding a pork pie. For the price of half of it he will love you. For the price of the other half, he will protect you from attack and lay down his life in defence of

yours” (32). While looking at this, it is clear that when a dog identifies its master who provides food for it, it does not give up its master to anyone.

Dogs help people to overcome sadness. When people are sad, they want to have a companion who consoles them and find it in dogs. This can be seen when Foster says, “Moreover, a dog of our own will help her to cope up with the melancholies” (34). Though people make themselves good companions, some people have fear in trusting other people. Wherein, in such situations, dogs become as the best choice in consoling people with their presence. Normally, dogs take care of people because they do not take care of themselves. They always try to safeguard their loved ones. Usually, when a bitch gives birth to puppies, it feeds milk and protects its children. If any street dogs attack its puppies, it safeguards by barking and fighting. Because of dog’s gratitude and selflessness, people also take care of them.

Fear is a psychological disorder that can be experienced when people are alienated. It is an unpleasant emotion which is exposed when one feels insecure. In the book, *How to Overcome Fear*, it has been stated as, “Whatever we see as separate from ourselves, inevitably becomes a source of fear” (Gupta 23). Likewise, When Ollie is separated from its own place, it experiences fear. Because of its fear, it does not feel comfortable with Foster. It also undergoes consumption disorder. “This type of fear [consumption disorder] related behaviour involves eating, swallowing or otherwise taking things into the body. Smoking, drinking, overeating, undereating and the taking of medicines or other drugs are all behaviour patterns” (Gupta 53).

Ollie’s consumption disorder is eating. When Foster gives food to Ollie, it consumes the food very fast than a normal dog. Escape is also a behavioural response to fear. This is proved when Ollie tries to escape from Foster. “I could sense him flinching before I even entered the house. Once I was in his space, he’d slink along the wall, creep into the next room to be out of my way” (108, 109). It is seen that when Ollie is afraid of Foster, it assumes that it is alienated and so it does not respond to Foster.

During Victorian Era, people are in need of emotional attachment. The portraits during eighteenth century consist of women who keeps lapdog with them. The pet culture became the prominent one during this era wherein they gave emotional support especially at the time of the death of the loved ones. Owning a dog, has made people to get relief from their grief, sorrow, and worries. Especially, women get benefited with this culture. Pets play a vital role in the life of men. When men own a pet animal, they become a responsible one with some characteristic changes within them. This results in the development of moral values in

men. Likewise, by owning Ollie, Foster becomes as a responsible one and he starts to understand others' feelings. This can be seen when Foster says, "If anything dysfunctional as it's been, it's *me* who is *his* emotional support" (171).

Dogs care for others than it cares for itself. Likewise, people also love dogs because it abandons people's loneliness. The thing which human beings want from others is love, care, and good treatment upon them. An advantage of owning a dog is that, somehow it makes people to engage with their society. When people have concern on dogs, they accompany and make companionship with people. As a result of dog's companionship, most of the people do not want to depend on other people. Because of dog's relationship, people have a strong mental health which leads in creating a peaceful life. Though there are many things that can be made as companions, the place of dogs, as a companion remains irreplaceable.

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The Role of Translation in Promoting Multilingualism

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ABSTRACT

In our rapidly globalizing world, multilingualism has emerged as a vital asset, empowering individuals and societies to navigate the complexities of our interconnected globe. The ability to speak and understand multiple languages is no longer a mere skill; it is a cornerstone of cultural diversity, effective communication, and mutual understanding among people of diverse linguistic backgrounds. This paper tries to focus on the phenomenon of multilingualism which is not confined to regions with a rich history of linguistic diversity but which is a global phenomenon that touches every corner of the planet. From cosmopolitan cities to rural villages, the coexistence of multiple languages is an inescapable reality.

Keywords: Translation, Multilingualism, Cultural Preservation, Global Communication, Education, Economic Opportunities.

Introduction

Translation, as the process of rendering meaning from one language into another, occupies a pivotal role in fostering and sustaining multilingualism. It goes beyond the mere exchange of words; it is a dynamic force that enables cultures to engage in a profound dialogue. First and foremost, translation serves as a powerful tool for breaking down language barriers. Translation allows individuals and organizations to surmount these linguistic hurdles and engage in meaningful exchanges. Furthermore, translation is a guardian of cultural heritage. It preserves the rich tapestry of stories, traditions, and ideas that are embedded within languages. Without translation, much of this heritage would be lost or inaccessible to those who do not speak the original language. Moreover, in the age of globalization, translation is indispensable for international communication. Lastly, translation plays a pivotal role in education and economic opportunities. It opens doors for individuals to access a wider range of educational resources and employment prospects. It is a key driver of economic growth, as it facilitates trade, tourism, and cultural exchange on a global scale. In this paper, we will delve into the manifold ways in which translation contributes to the promotion and preservation of multilingualism, illustrating its significance as a cornerstone of our interconnected world.

Bridging Language Barriers

Translation serves as a bridge between languages, allowing individuals who speak different languages to understand and communicate with one another effectively. In a globalized world, where people from diverse linguistic backgrounds interact regularly, translation ensures that information, ideas, and knowledge can be shared across languages. This enables cultural exchange, facilitates diplomacy, and supports international relations.

Preserving Cultural Heritage

Languages are carriers of culture, and translation helps preserve and share cultural heritage across linguistic boundaries. By translating literature, art, historical documents, and other forms of cultural expression, translators ensure that the rich tapestry of human creativity and history is accessible to a broader audience. This preservation of diverse cultural narratives contributes to a deeper understanding and appreciation of global heritage.

Facilitating International Communication

Multilingualism is essential for international organizations, diplomacy, and business interactions. Translation facilitates effective communication in international contexts, enabling negotiations, agreements, and collaborations to take place smoothly. Without translation, misunderstandings and misinterpretations could hinder diplomatic relations and hinder economic development.

Fostering Educational and Economic Opportunities

In multilingual societies, translation plays a vital role in education and commerce. It allows access to educational resources in different languages, making learning more inclusive and accessible. Furthermore, translation contributes to economic growth by enabling businesses to reach broader markets and audiences. Localization, a specialized form of translation, tailors products and services to specific linguistic and cultural markets, thereby enhancing market penetration.

Promoting Language Learning

Translation serves as a valuable tool for language learners, aiding them in understanding and mastering new languages. Translated texts, audiovisual materials, and language learning apps assist learners in comprehending complex concepts and linguistic nuances. Moreover, exposure to translations encourages individuals to explore different languages and cultures, fostering a curiosity for multilingualism.

Challenges and Ethical Considerations

While translation is a powerful tool for promoting multilingualism, it also raises ethical and cultural considerations. Translators must navigate issues related to accuracy,

cultural sensitivity, and authenticity. Careful consideration of context and cultural nuances is essential to ensure that translations do not distort or misrepresent the original meaning.

Technology's Impact on Translation

Advancements in technology, particularly machine translation and AI-driven tools, have revolutionized the translation landscape. While these tools offer speed and efficiency, they also raise concerns about the preservation of human expertise, cultural nuances, and context awareness in translation. Human translators bring cultural insight and context that automated systems may lack, highlighting the irreplaceable role of human translators in promoting multilingualism.

Conclusion

Translation stands as a crucial pillar in our interconnected world, promoting and preserving multilingualism in manifold ways. It serves as a bridge, connecting people of diverse linguistic backgrounds, enabling the exchange of knowledge, ideas, and culture. Translation safeguards our rich cultural heritage, ensuring that the stories and traditions embedded within languages are not lost to time. It facilitates effective international communication, supporting diplomacy, business, and education. Moreover, translation fosters language learning and curiosity, encouraging individuals to embrace multilingualism.

However, we must acknowledge the challenges and ethical considerations that accompany translation. Translators bear the responsibility of preserving accuracy, cultural sensitivity, and authenticity, navigating the complexities of language and culture with care. Additionally, the advent of technology, such as machine translation and AI, has transformed the translation landscape, emphasizing the irreplaceable role of human translators in preserving cultural nuances and context awareness.

As we navigate our rapidly globalizing world, let us recognize and celebrate the power of translation in promoting mutual understanding, cultural diversity, and effective communication. By embracing the art of translation and valuing the contributions of skilled translators, we can ensure that multilingualism continues to thrive, enriching our shared human experience.

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இயற்கையில் இன்புற்ற இலக்கிய மாந்தர்கள்

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கட்டுரைச் சுருக்கம்

தமிழ் இலக்கியங்கள் வாழ்க்கை சார்ந்ததாக உள்ளன. பண்டைய மக்கள் இயற்கையோடு இயைந்து வாழ்ந்தனர். அவர் தம் இன்ப துன்பங்களை இயற்கையோடு இணைத்துக் கண்டனர். இயற்கையின்றி மனிதகுலம் வாழ இயலாது. பழந்தமிழ் இலக்கியங்கள் இவற்றைத் தெள்ளிதின் புலப்படுத்துகின்றன. அ.றிணைப் பொருட்களுக்கு உயிரும் உணர்வும் கொடுத்து அவற்றை உயர்திணைப் போன்றே பாவித்து புலவர்கள் பாடியுள்ளனர்.

முன்னுரை

இயற்கையை வர்ணித்தும் போற்றியும் ஒப்பிட்டும் பாட்டு, தொகை மட்டுமன்றி காப்பியம், பக்தியிலக்கியம், சிறிலக்கியம் போன்றவையும் அமைந்துள்ளன. இவை மட்டுமன்றி பிற்கால இலக்கியங்களும் அதனைத் தொடர்ந்ததால் தான் காக்கை குருவி எங்கள் சாதி என்று பாடினார் பாரதியார். இவ்வாறு அ.றிணைப் பொருட்களை உயர்திணையாகப் பாவித்ததைச் சங்க இலக்கியம் முதல் தற்கால இலக்கியம் வரைக் காணலாம்.

தொல்காப்பியம்

இலக்கியங்களுக்கு இலக்கணம் கூறிய செம்மொழி தமிழின் அடையாளமான தொல்காப்பியர் அக இலக்கணம் கூறும் போது இயற்கையை முன்னிறுத்தியே அன்பின் ஐந்திணையை விவரித்துள்ளார். கருப்பொருளும் உரிப்பொருளும் முதற்பொருளான நிலத்தையும் பொழுதையும் மையமாக வைத்தே வரையறுக்கப்பட்டன. அகம் சார்ந்தவை இயற்கையோடு இணைத்துக் கூறப்பட்டுள்ளன. உதாரணமாகக் குறிஞ்சிக்குரிய உரிப்பொருளான புணர்தலுக்குக் குறிஞ்சி நிலத்திற்குரிய முதற்பொருள் காரணமாகின்றது.

கூதிர் யாமம் முன்பனி என்றிவை ஓதிய குறிஞ்சிக்குரியவாகும்.

பெரும் பொழுதான குளிர் காலமும் மாலை நேரத்தில் பனிப்பொழியும் முன்பனிக்காலமும் சிறுபொழுதான யாமமும் சேர்ந்து உரிப்பொருளை உருவாக்குகின்றன. அவ்வாறே கருப்பொருளுக்கும் முதற்பொருள் காரணமாகின்றது. அகவாழ்வில் மட்டுமன்றி புறவாழ்க்கையிலும் இயற்கையை இணைக்க முற்பட்டதால் தான் வெட்சி முதல் வாகை வரையிலான புறத்திணைகளுக்கு மலர்களை அடையாளமாக்கி ஒவ்வொரு மலருக்கும் அர்த்தம் கண்டனர் பழந்தமிழர். இயற்கையைத் திணை ஒழுக்கத்துடன் ஒன்றாக இணைத்தே சங்கபுலவர்கள் காண்கிறார்கள். தொல்காப்பிய கருப்பொருள் முழுவதும் இயற்கையை முன்னிறுத்தினாலும் அவற்றுள் ஒன்றான தொழில் இயற்கையுடன் இயைந்து மனிதன் இன்புற்றதனைக் காட்சிப்படுத்துகின்றது.

நற்றிணை

நற்றிணை நாயகி விளையாடும் போது மறந்து விட்ட விதையானது முளைத்ததும், அதற்குப் பாலாற்றி வளர்த்த தலைவி, அன்னை உங்களை விட உங்கள் சகோதரி சிறந்தவள் என்று கூறியதால் புன்னை மரத்தைத் தன் சகோதரியாகவே பாவித்து தலைவனை அவ்விடத்தில் சந்திக்க நாணுவதாகக் கூறுகிறாள். இது குறியிடம் மறுத்தலாக இருந்தாலும் அக்கால மக்களின் மனஉணர்வினைப் புலப்படுத்துகின்றது. அ.ஃ.றிணை உயிர்களை ஆற்றிவு மனிதனைப் போல் பாவித்ததைக் காணமுடிகின்றது. பின்வரும் பாடல் அதனை விவரிக்கின்றது.

விளையாடு ஆயமொடு வெண் மணல் அழுத்தி
மறந்தனம் துறந்த காழ் முளை அகைய
நெய் பெய் தீம் பால் பெய்து இனிது வளர்ப்ப
நும்மினும் சிறந்தது நுவ்வை ஆகும் என்று
அன்னை கூறினள் புன்னையது சிறப்பே
அம்ம நாணுதும் நும்மோடு நகையே... (நற் - 172)

குறுந்தொகை

தலைவன் திருமணத்திற்குக் காலம் தாழ்த்தியதால் கலக்கமுற்ற குறுந்தொகைத் தலைவி தன் தோழியிடம் புலம்பும் போது, தலைவனுடனான இயற்கைப்புணர்ச்சியின் போது அவ்விடத்தில் யாரும் இல்லை. அவன் மட்டுமே இருந்தான். ஒருவேளை அவன் பொய்த்துவிட்டால் நான் என்னசெய்வேன்? ஒழுகுகின்ற நீரோட்டத்தில் ஆரல்மீனைத் தேடிக் கொண்டிருந்த திணையின் தாள் போன்ற சிறிய பசுமையான கால்களையுடைய நாரையும் அங்கிருந்தது. அதுவும் எங்களைப் பார்க்கவில்லை

யாரும் இல்லை தானே கள்வன்
தானது பொய்ப்பின், யானெவன் செய்கோ?
தினைத்தாள் அன்ன சிறுபசுங் கால்
ஒழுகுநீர் ஆரல் பார்க்கும்
குருகும் உண்டு தான் மணந்த ஞான்றே (குறு - 25)

என்கின்றாள். இப்பாடல் சாட்சிக் கூறும் அளவுக்கு மனிதனைப் போன்று நாரையை எண்ணிய தலைவியின் மனநிலையை மட்டுமன்றி அக்கால மக்களின் உளப்பாங்கையும் எடுத்துரைக்கின்றது. இது போன்ற மற்றொரு பாடலையும் குறுந்தொகையில் காணலாம். பாமரரும் அறிந்த இறையனார் பாடியதாகக் கருதப்படும் மிகப்பிரபலமான

கொங்கு தேர் வாழ்க்கை அம் சிறைத் தும்பி
காமம் செப்பாது கண்டது மொழிமோ
பயிலியது கெழீஇய நட்பின் மயில் இயல்
நறியவும் உளவோ நீஅறியும் பூவே (குறு - 2)

எனும் பாடலே அது. பூக்கள் தோறும் சென்று தேனை ஆராய்ந்து உண்ணுகின்ற வாழ்க்கையையுடைய வண்டே! நீ அறிந்த மலர்களில், மயில் போன்ற சாயலையுடைய என்

தலைவியின் கூந்தலைவிட மணமிக்க மலர் உள்ளதா? நான் விரும்புவதைக் கூறாமல் நீ கண்டதைக் கூறுவாயாக! என்று வண்டு கூறாது என்று தெரிந்தும் அதனை மனிதனைப் போன்று கருதி கேட்பதை அறிய முடிகின்றது. இயற்கையுடன் ஒன்றித்து வாழ்ந்த மக்கள் இயற்கைக்குக் கொடுத்த மதிப்பினை இப்பாடல் மூலம் கண்டு தெளியலாம்.

செங்களம் படக்கொன் றவுணர்த் தேய்த்த

செங்கோ லம்பிற் செங்கோட்டி யானைக்

கழறொடிச் சேஎய் குன்றம்

குருதிப் பூவின் குலைக்காந் தட்டே (குறு - 1)

எனும் பாடலில் தலைவன் தலைவிக்குப் கையுறையாகச் செங்காந்தள் மலர்களைத் தோழியிடம் வழங்கியது இடம்பெற்றுள்ளது. இதன் வாயிலாகத் தலைவன் தலைவிக்கு வழங்கும் கையுறைப் பொருட்களில் ஒன்றாக மலர்கள் இருந்தது தெளிவாகின்றது.

தலைவனைப் பிரிந்த தலைவி அந்த பிரிவுத்துயரை எப்படி பொறுத்துக்கொள்வாளோ என்று கவலைப்பட்ட தோழியைத் தேற்றும் விதமாகத் தலைவி நான் மட்டுமா உறங்காமல் இருக்கிறேன். கடலைகளைப் பார் அவையும் கூட உறங்கவில்லை என்று தன்னுடன் கடலை ஒப்பிடுகின்றாள் தலைவி. அவளின் பிரிவுத்துயர் இயற்கையையும் சகஉயிராகப் பாவித்து மதித்த அக்கால மக்களின் மனநிலையைக் காட்டுவதுடன் அவற்றைச் சார்ந்த வாழ்க்கை முறையையும் எடுத்துரைக்கின்றது.

அதுகொ றோழி காம நோயே

வதிசூரு குறங்கு மின்னிழற் புன்னை

உடைதிரைத் திவலை யரும்புந் தீநீர்

மெல்லம் புலம்பன் பிரிந்தெனப்

பல்லத முண்கண் பாடொல் லாவே (குறு - 5)

அகநானூறு

பொருள் தேடச் சென்ற தலைவன் கார்காலம் தலைவியைக் காணத் தேரில் விரைந்துவருகிறான். வரும் வழியில் தேரினது மணி ஓசை கேட்டு ஒன்று சேர இருக்கும் ஆண்மாமும் பெண்மாமும் மருண்டு விலகிவிடக் கூடாதென்று பிற உயிரிகளுக்கு இடையூறாக தான் இருக்கக் கூடாது என்று எண்ணி தேர்ப்பாகனிடம் மணியின் நாவை ஒலியெழுப்பாதவாறுக் கட்டி வைத்து தேரை மெதுவாக ஓட்டுமாறு கூறுகின்றான்.

இடி மறந்து ஏமதி வலவ! குவிமுகை

வாழை வான் பூ ஊழுறுபு உதிர்ந்த

ஒழிகுலை அன்ன திரிமருப்பு ஏற்றொடு

கணைக் கால் அம் பிணைக் காமர் புணர் நிலை

கடுமான் தேர் ஒலி கேட்பின்

நடுநாட் கூட்டம் ஆகலும் உண்டே (அக - 134)

இதில் அ.ஃறிணை உயிர்களைத் தமக்கிணையாகக் காணும் தலைவனின் மனநிலையை அறிய முடிகின்றது. அவற்றின் இன்பத்துக்குத் தம்மால் துன்பம் வரக்கூடாது என்ற பழந்தமிழரின் எண்ணவோட்டத்தை இதன் மூலம் தெளியலாம்.

குறிஞ்சிப்பாட்டு

முவாயிரம் ஆண்டுகளுக்கு முன்பே நேர்த்தியாக 99 வகையான மலர்களை குறிஞ்சிப்பாட்டில் பட்டியலிடும் (குறி.பா - 61 - 96) கபிலர் அந்நூல் முழுவதும் தலைவியையும் அவள் தோழியரையும் இயற்கையுடன் இணைந்து இன்பம் துய்க்க வைக்கின்றார். அருவி நீராடி பூக்களைக் கொய்து விளையாடி ஆற்றில் குளித்து மகிழ்ந்து பகல் முழுவதும் இயற்கை இன்பத்தை அள்ளிப் பருகியுள்ளதை அறிய முடிகின்றது.

புதுப்புனலாடல்

பண்டைத் தமிழரின் விழாக்களை உற்று நோக்கினால் அவை இயற்கையைப் போற்றுவதற்காக நடத்தப்பட்டவை என்பதில் ஐயம் இல்லை. ஆற்றில் வெள்ளம் வரும் போது புதுப்புனல் நீரால் விழாவாகக் கொண்டாடப்பட்டது. நீரை வாழ்த்தி வழிபடுதலும் வரம் வேண்டலும் இவ்விழாவின் நோக்கமாகும். பரிபாடலில் வையைப் பாடல் புதுப்புனலாடலை எடுத்துரைக்கின்றது. இதேக்காட்சியை கண்ணதாசனின் ஆட்டனத்தி ஆதிமந்தியிலும் காணலாம். ஆடல் பாடலுடன் பலவிதமான கலைநிகழ்ச்சிகளுடன் காவிரியாற்றில் புதுப்புனல் வருவது விழாவாகக் கொண்டாடப்பட்டது. இதன் பிரதிபலிப்பே தற்காலத்தில் ஆடிப்பெருக்கு. இது போன்றே இந்திரவிழா, வேனில்விழா என அக்காலத்தில் பலவதமான விழாக்கள் கொண்டாடப்பட்டதை இலக்கியங்கள் வழி அறியமுடிகின்றது.

முடிவுரை

பண்டைத் தமிழ் இலக்கியங்களில் இயற்கைக் காட்சிகள் இரண்டறக் கலந்துள்ளன. ஆற்றிவு மனிதன் தன்னைவிட அறிவில் குறைந்த அ.ஃறிணை உயிர்களை மதித்து தமக்கிணையாகக் கண்டான். முல்லைக்குத் தேர் கொடுத்த பாரியும், மயிலுக்குப் போர்வை நல்கிய பேகனும் அவற்றை அ.ஃறிணை உயிர்கள் என்று ஒதுக்காது தம்மை ஒத்த உயிராக மதித்துப் போற்றினர். பழந்தமிழர் இயற்கைச் செல்வங்களை அனுபவித்ததுடன் பாதுகாக்கவும் செய்தனர் என்பதற்குப் பண்டை இலக்கியங்கள் சான்று பகர்கின்றன.

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கட்டுரைச் சுருக்கம்

சமூகம் நலம்பெறவும் வளம்பெறவும் அமைதி தேவை. நம்மில் அமைதி நிலவிட நமக்குள் ஒற்றுமை, விட்டுக்கொடுத்தல், பொறுமை போன்ற நற்குணங்கள் தேவை. இன்றைய சமூகம் வன்முறை கலாச்சாரம், போர்க்கலவரம், இயற்கைச் சீற்றம் எனப் பல்வேறு சூழலில் சிக்கித் தவிக்கிறது. இச்சூழலுக்கான காரணத்தைக் கி.பி. முதலாம் நூற்றாண்டில் தோன்றிய திருக்குறள் விளக்குகிறது. திருக்குறள் வல்லறத்தை விரும்பவில்லை, நல்லறத்தையே விரும்புகிறது. இன்னா செய்யாமை, வெகுளாமை, கொல்லாமை ஆகிய அதிகாரங்களில் குறிப்பிடப்பட்டுள்ள குறட்பாக்கள் பிறருக்கு நல்லது செய்தலே தலையாய அறம் எனவும் பிறரிடம் சினம் கொள்ளாதிருத்தலே மனிதனுக்கு நலம் எனவும் கூறுகின்றன. பிற உயிர்களுக்குத் தீங்குச் செய்யாது, கொல்லாது விடுவதையும் மேற்கோள் காட்டுகின்றன. பிறருக்கு இன்னா செய்யாது, பிறர் மீது வெகுளாது, பிற உயிர்களைக் கொல்லாது வாழ்ந்தலே அறம் என்பதை இந்த ஆய்வுக்கட்டுரை விளக்குகிறது.

முன்னுரை

மனித இனம் தொடங்கிய காலம் தொட்டு சண்டைகளும் உடனே தொடங்கிவிட்டது எனலாம். மனித இனமாகவும், விலங்கினமாகவும், பறவையினமாகவும் இனங்களில் வேறுபட்டாலும் சண்டைகளில் ஓரினமாகத்தான் கொள்ளமுடியும். சண்டையின் தொடக்கம் பசி போக்கும் நோக்காக இருந்தது. அறிவியலோ இதனை உணவுச்சங்கிலி என வரையறுத்தது. மனித இனங்களோ வல்லினம் மெல்லினங்களுக்கு இடையேயான இனக்குழுவின் சண்டையாக வரையறுத்து நின்றது. வல்லான் வகுத்ததே அறம் எனப்பட்டது. வல்லான் வாழ்வான் என்பதே வரலாறு. சமகாலம் இனப்படுகொலையின் காலமாக அறுதியிடலாம். இலங்கையின் இனப்படுகொலையைத் தொடர்ந்து நடந்துவரும் ரஷ்யா, உக்ரைன் போர். இப்போது தொடங்கியிருக்கும் இஸ்ரேல், பாலஸ்தீனப் போர்கள் எல்லாமே வல்லாதிக்கத்தின் வெளிப்பாடே. தமிழன் தன்னின வாழ்வை, தனக்கென சமந்தியை சிங்களர்களோடு சண்டையிட்டுப் பெறவிழைந்ததன் விளைவு முள்ளிவாய்க்காலில் முடிந்ததோடு முள்வேலி முன்கலோடும் தொடர்கிறது. வள்ளுவன் வரிகளை உள்ளம் இருத்தியிருந்தால் உலகப்பொதுமறை திருக்குறள் என்பது நிரூபணமாயிருக்கும்.

அறம்

அறம் செய விரும்பு, ஆறுவது சினம் என ஒளவைப் பாட்டி ஆத்திசூடி தந்தது அறத்தாலன்றோ? அன்றி மறத்தாலன்று. தமிழ் மறையான வள்ளுவனும் அறம் பேச மறக்கவில்லை. ஏனெனில் தமிழர் தம் வாழ்வில் அறம் இல்லை, மாறாக அறமே வாழ்வாக அமைந்தது. எனவேதான் இல்லம் குடும்பம் என்பதைக் கூட இல்லறம் என வரையறுத்தனர். ஆணும் பெண்ணும் சேர்ந்து இயங்கும் குடும்ப உறவில் ஒவ்வொரு நிகழ்விலும் அறம்

அடிப்படையாக அமைந்தது. திருவள்ளுவர் தான் யாத்த முப்பாலுக்கு அறத்துப்பாலை முதல் பகுப்பாக வைத்தார். ஏனெனில்

அறனெனப் பட்டதே இல்வாழ்க்கை அ.தும்

பிறன்பழிப்ப தில்லாயின் நன்று. (குறள் - 49)

அறம் என்று சிறப்பித்துச் சொல்லப்பட்டது இல்வாழ்க்கையே ஆகும். அதுவும் பிறரால் பழிக்கப்படாத தூய்மையுடையதனால் மிக நல்லது என்கிறார் வள்ளுவர். அத்தகு அறத்துப்பாலில் இல்லற இயல், துறவற இயல், ஊழியல் என மூன்று பெரும்பிரிவுகளை வரையறுத்துள்ளார். அதனின்றும் அறத்துப்பால், பொருட்பால், இன்பத்துப்பால் என வகுக்கும் வள்ளுவர் முதற்பிரிவுக்கு அறத்துப்பால் எனப் பெயரிட்டாலும் பொருளும் இன்பமும் அறத்தை விடுத்து இல்லை. மனத்தூய்மையே அறம் என்பதை

மனத்துக்கண் மாசிலன் ஆதல் அனைத்தறன்

ஆகுல நீர பிற. (குறள் - 34)

என்னும் குறள்வழி ஒருவன் தம் மனத்தில் குற்றமில்லாதவனாக இருக்கவேண்டும். அதுவே அறம். மனத்தூய்மையற்ற பிற யாவும் வீண் ஆரவாரத்தன்மையே என்னும் வாக்கினை வரம்புகழ் வள்ளுவன் வழி நன்கறியலாம்.

போர்த்தொழில்

முப்பால் உரைத்த மூத்தப்புலவன் வள்ளுவனின் அறத்துப்பாலில் வெகுளாமை, இன்னா செய்யாமை, கொல்லாமை என்ற மூன்று அதிகாரங்கள் ஒன்றனுள் ஒன்று தொடர்புடையதாக அமைகிறது. கோபமும், தீங்கு செய்தலும், கொடுந்தொழிலாம் போர்த்தொழிலுக்கு அடிப்படை. போரின் இறுதி உயிர்ப்பலி. இயற்கை வாழ்வில் மரணம் தவிர்க்க இயலாத ஒன்று. பிறப்புக்கும் இறப்புக்கும் இடைப்பட்ட வழிப்பயணம் நிறை மூப்பெய்தி முடிவது நன்று. ஆனால் சினங்கொண்டு சண்டையிட்டு, இன்னாசெய்து கொலையுறுதல் என்பது இயற்கைக்கு முரணான ஒன்று. உலகம் ஏற்காத ஒன்று கூட. சமகால போர்த்தொழில் அக்காலத்தும் பெரிதும் வியந்து பாராட்டப்பட்டன. எனவேதான் அகம், புறம் என இலக்கியம் பகுக்கப்பட்டன. வாழ்வியலும் அவ்வாறுதான் அமைந்தன. சமூகத்தின் வெளிப்பாடே இலக்கியம் என்பதால் இலக்கியத்தின் கருக்களாகப் போர்ச்செய்திகள் மிகுந்துக் காணப்படுகின்றன. அவை தமிழினத்தின் போர்ச்சிறப்பைப் பறைசாற்றினும் போரில் அழிந்த வேல்களைவிட இறந்த வீரர்களின் அழிவு பேரழிவன்றோ? எனவேதான் போருக்கும் நியதிகளை வரையறுத்திருந்தார்கள் முன்னோர்கள்.

எத்தொழிலிலும் அறம் வரையறுக்கப்பட்டது. போர்த்தொழிலிலும் அது கடைபிடிக்கப்பட்டது. போர் நடைபெறுவதற்கான காலம் சூரியன் உதிப்பது முதல் சூரியன் மறையும் வரை எனவும், குழந்தைகள், பெண்கள் போரில் கொல்லப்படுவது தவிர்க்கப்பட வேண்டுமெனவும், ஆயுதம் இல்லாமல் நிராயுதபாணியோடு நிற்கும் ஒருவரோடு சண்டையிடுவதில்லை என்பனவும் பண்டைய போர்த்தொழிலுக்கான விதிமுறைகளில் அடங்கும். எனினும் உயிர்க்கொல்லும் இப்போர்த்தொழிலை வள்ளுவன் ஏற்காததன் விளைவாகவே

போருக்கு அடிப்படைக்காரணமான கோபம், இன்னாசெய்தல் என்னும் இரண்டையும் அறத்துப்பாலில் ஏற்றி வைத்தான்.

வெகுளி என்னும் கோபம்

கோபம் கொண்டவனை அழிக்கும் என்பது சாதாரண வாக்கு. கோபம் மனிதனின் ஓர் குணமாகவே அமைகிறது. கோபம் இருக்குமிடத்தில் குணமிருக்கும் என்று கோபம் கொண்டவரையும் அவனைத்துச் செல்வது சமூகத்தின் மனப்பாங்கு. இல்லறவெளியில் கோபம் சில நல்லறங்களைக் கெடுத்து தீமை பயத்து நிற்கும். நெடும்பகையை உருவாக்கும் அதே கோபம் உறவைக் கடந்து நிற்கும் போது, அது பேரழிவின் பெருங்குணமாக மாறிவிடுகிறது. கோபம் தன்னையே அழிக்கும் பகை என்கிறார் வள்ளுவர். எனவே தான்

தன்னைத்தான் காக்கின் சினங்காக்க காவாக்கால்

தன்னையே கொல்லும் சினம். (குறள் - 305)

ஒருவன் தன்னைத்தானே துன்பம் எய்தாமல் காத்துக்கொள்ள விரும்பினால் தன் மனத்தில் சினம் வராமல் காக்கவேண்டும். அவ்வாறு சினம் வராமல் காக்காவிட்டால் அச்சினம் தன்னையே அழித்துவிடும் என்பது உண்மை. இவ்வாறு தன் சினம் தன்னை மட்டும் அழித்தால் இவ்வழிவு அவனை மட்டும் பாதிக்கும் என்பதல்ல. மாறாக தன்னை நேரடியாகப் பாதித்து, தன்னைச் சார்ந்தோரையும் மறைமுகமாகப் பாதிக்கும்.

வள்ளுவன் வான்சிறந்து நிற்கும் இடம் இக்குறளில்தான். ஏனெனில் கோபத்தின் அழிவை இக்குறளிலின்றி எக்குறளிலும் இப்படி இலக்கணம் காணவியலா. கோபத்தை அதன் அழிவைக் கண்முன் கண்ட ஒருவரால் மட்டுமே இத்தகு கருத்தைக் குறளில் வைக்கமுடியும். இக்குறள் சினத்தால் அழியும் சமூகத்தின் குரலாக அமைகிறது.

சினமென்னுஞ் சேர்ந்தாரைக் கொல்லி இனமென்னும்

ஏமப் புணையைச் சுடும். (குறள் - 306)

சினம் என்னும் நெருப்பு தன்னைச் சேர்ந்தாரை மட்டுமல்லாமல், அவருடைய துன்பக்காலத்தில் துன்பக்கடலுள் அழுந்தாமல் கரையேற்றுகின்ற படகுபோல் உதவும் அவரது இனத்தாரையும் சுட்டழிக்கும்.

தம் கண்முன்னே கண்ட போரினைத் தன்னின்பு பேரழிவினை இக்குறள் நமக்குச் சுருக்கி உரைக்கிறது. இனப்படுகொலையில் இழந்தவர்கள் தம் வீரமைந்தார்கள் மட்டுமல்ல, இவர்களுக்கு ஏமப்படகாய் இருந்தவர்கள் மட்டுமல்ல, இன்னும் பலரும் மட்டுமல்ல, இன்று நடைபிணமாய் வாழ்பவர்களும் கூட. கண்ணிழந்தோர் உண்டு, காலிழந்தோர் உண்டு, இன்றும் இதயம் நொறுங்கி வாழ்வோரும் உண்டு. எல்லாம் சினத்தால் வந்த இனத்தின் பேரழிவே. இன்றளவும் துடைக்க இயலா துயராகவும், கடக்க இயலா துன்பக்கடலாகவும் சினம் அமைந்தது கண்கூடு.

இணரெரி தோய்வன்ன இன்னா செயினும்

புணரின் வெகுளாமை நன்று. (குறள் - 308)

ஒருவருக்குச் சினம் என்னும் சிந்தை தனக்கு ஒருவர் அடர்ந்த தீயில் கருகுவதைப் போல் தொடர்ந்து தீங்கிழைத்தாலும் அவர் மேல் சினம் வராமல் பாதுகாத்துக் கொள்வது நல்லது என்கிறார் வள்ளுவர்.

இன்னா செய்யாமை

கோபம் வரவில்லையெனில் அல்லது கோபத்தை அடக்குவதன் மூலம் பிறருக்குத் தீங்கிழைக்கும் எண்ணம் ஏற்படுவதில்லை. தனிமனித கோபமே சமூக கோபமாக வளர்ந்துவிடுகிறது. அது நாடு கடந்து, எல்லைகளைத் தாண்டி, கண்டம் விட்டு கண்டம் பாய்ந்து நிற்கிறது. நில எல்லைகளைத் தனதாக்கிக் கொள்வதிலும் அத்தகு சிந்தனையில் எதிர்நிலையினருக்குத் தீங்கிழைப்பதும், தொடர்ந்து அடர்ந்த தீயினைப் போல் சுட்டெரிப்பதும், போர்த்தொழிலின் மூலமாக அமைகிறது. ரஷ்ய அதிபருக்கு ஏற்பட்ட கோபம் உக்ரைனுக்குத் தீங்கிழைத்து, உயிர்க்கொலைக்கு வழிவகுக்கிறது. நாட்டின் எல்லைகளை விரிவுபடுத்தவும் எண்ணெய் வளங்களைக் கைப்பற்றவும், சொந்தநாட்டினரையும் அண்டைநாட்டினரையும் அழிவுப்பாதைக்கு இட்டுச்சென்றது. நவீனகாலத்தின் அறிவியல் தொழில்நுட்ப முன்னேற்றங்கள் மூளையைக் கசக்கிப் பிழிந்து அழிவுக்கு அடித்தளமிடுகிறதே அன்றி, இதயத்தை மறந்துவிடுகிறது. இதன் வெளிப்பாடே குடியிருப்புப்பகுதிகள், மருத்துவமனைகள் என மக்களை அழித்து, மண்ணைக் கைப்பற்றப் போரை மேற்கொள்கின்றனர். இலங்கையின் முள்ளிவாய்க்கால் போரில் மக்களை மனித கேடயமாக்கினர். வான்வழித்தாக்குதல் நடத்துவோர்க்கும், பீரங்கி வழிதாக்குதல் நடத்துவோர்க்கும் இதயமும் இரக்கமும் இல்லைதானே? தன் அழிவைத் தானே தேடுவதுபோல் அறத்தின் எந்த மாண்பையும் நினைவில் கொள்ளாமல் இன்னாசெய்தலொன்றே காரணமாகிக் கோடிக்கனல் கக்கி பெரும் பேரழிவாக இருநாட்டுமக்களுக்கும் தொடர் இன்னலுக்கு தொடர்ந்து வழிவகுக்கிறது. இத்தகைய நிலையை வள்ளுவர்

தன்னுயிர்க் கின்னாமை தானறிவான் என்கொலோ

மன்னுயிர்க் கின்னா செயல். (குறள் - 318)

தன் உயிர்க்குத் தீங்கானவை இவை என்று அறிந்தவன் மற்ற உயிர்களுக்கு அத்தீயவற்றைச் செய்தல் என்னக் காரணம் பற்றியோ? என்று இன்னா செய்பவர்களைச் சிந்திக்கத் தூண்டுகிறார்.

கொல்லாமை

வள்ளுவன் கொல்லாமைக்கு எதிரானவன் என்பதைக் கொல்லாமை அதிகாரத்தின் குறளே சாட்சி.

அறவினை யாதெனின் கொல்லாமை கோறல்

பிறவினை எல்லாந் தரும். (குறள் - 321)

என்னும் குறளில் அறச்செயல் எது என்றால் ஓர் உயிரையும் கொல்லாமையாகும். கொல்லுதல் என்பது பிற தீவினைகள் எல்லாவற்றின் பயனையும் ஒருங்கே தரும் என உரைப்பதன் மூலம் கொல்லாமை கொடுந்தொழிலின் தீவினை என்பதை அறியமுடிகிறது. மேலும் வள்ளுவர் கூற்றுவன் செல்லத் தயங்கும் செயலாக,

கொல்லாமை மேற்கொண் டொழுகுவான் வாழ்நாள்மேல்

செல்லா துயிருண்ணுங் கூற்று. (குறள் - 326)

என்னும் குறள் வாயிலாகக் கொல்லாமையை விரதமாகக் கடைபிடித்து நடப்பவன் வாழ்நாள் மேல் உயிரைக் கவரும் எமன் அவனது உயிரைக் கவரச் செல்லமாட்டான் என்றுரைக்கிறார். மதங்கள் எதுவானாலும் மனிதன் நல்லவனாக வாழ்ந்தால் போதும். மனிதனை மனிதன் கொலை செய்ய மதமும் தேவையென்றால் இறைமதம் உரைக்கும் மறைமதம் எதற்கு? அனைத்து உயிரும் ஆக்கம் பெற உரைக்கும் பொதுமறையாம் குறள் ஒன்றே போதுமே. நாம் படிக்க, நாம் நன்றாக நடக்க.

முடிவுரை

பிற உயிர்களை வெல்லும் சொற்களையும் செயல்களையும் செய்யாமல், பிற உயிர்களைக் கொல்லும் கொடுந்தொழிலைக் கைக்கொள்ளும் மனித இனமும், ஆட்சி அரசியலும் அதிகாரமும் ஒன்றிணைந்து செயல்படுகிறது. அமைதி தேடுவோர்கள் தேடிக்கொண்டே இருக்கிறார்கள். அதிகார வர்க்கத்தினரோ அறம் மறந்து, இனம் கொண்டு, பிறருக்குத் தீங்கிழைத்துக் கொலைத்தொழில் செய்கின்றனர். வள்ளுவன் வரையறுத்த இன்னாசெய்யாமை, வெகுளாமை, கொல்லாமை அதிகாரங்களைப் பாடம் செய்து மனத்திலிருத்தி செயற்பட்டால் கொல்லும் செயல் இன்றி வாழும் வழி பிறந்திருக்கும். பிறக்கும் எல்லா உயிர்க்கும் இயற்கை மரணம் கிடைத்திருக்கும்.

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கயமனாரின் இயற்கைக்காட்சியும் உவமைநலனும்

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கட்டுரைச் சுருக்கம்

சங்க இலக்கியங்களில் பல புலவர்கள் பல்வேறு விதங்களில் இயற்கையை உவமை நலனுடன் பாடியுள்ளனர். இக்கட்டுரையில் கயமனாரின் பாடல்களில் இயற்கைக்காட்சியும் உவமை நலனும் எடுத்தாண்டுள்ள விதம் சுட்டப்பட்டுள்ளது. கோடைக்காலத்தில் ஏற்படும் மாற்றங்கள் அதனால் உயிரினங்களின் நிலைப்பாடு ஆகியவை ஆய்வு செய்யப்பட்டுள்ளன. அடுத்து கயமனார் பாலை நிலக்காட்சிகளை எவ்வாறு வெளிப்படுத்துகின்றார், அங்கு வாழும் உயிரினங்கள் என்னென்ன துன்பங்களை அனுபவிக்கின்றன என்பவற்றையும் காணலாம். இயற்கையோடு இணைந்த பழக்கவழக்கங்கள் மற்றும் வரலாற்று குறிப்புகள் ஆய்வு செய்யப்பட்டுள்ளன. கயமனார் ஒருபொருளைக் கண்டதும் அதனோடு ஒப்புமை உடைய மற்றொரு பொருளையும் அககண்ணில் கொணர்ந்து ஒப்பிட்டு மகிழ்கின்றார். இத்தகைய அனுபவமே அவர் இயற்றும் பாடல்களில் உவமைகளாக அழகு பெற்றிருக்கின்றன. இவற்றை இக்கட்டுரையில் விரிவாகக் காண்போம்.

முன்னுரை

இயற்கையைப்பாடி அக்காட்சி நலத்தால் புகழ்பெற்ற புலவர்களுள் குறிப்பிடத்தக்கவர் கயமனார். ஐம்புலனும் உணர்வு பெறும்படி எழுதப்பட்ட அவரது பாடல்கள் வழி அவரது புலமை நமக்குத் தெளிவாகப் புலனாகிறது. இயற்கை காட்சியை சுவை, ஒளி, உணர்வு, ஓசை, மனம் என்னும் ஐந்து வகைகளாலும் அவர் கண்டுகளித்துள்ளார் என்பது நமக்குப் புலப்படுகிறது. அவற்றை தம் பாடல்களில் சொல்லோவியமாக்கியுள்ளார்.

ஒன்றைக் காணும் போது அது போன்ற மற்றொன்று நினைவுக்கு வருவது மனித இயல்பு. புலவரின் கண் பொருளைக் கண்டு அவற்றின் வடிவையும் நிறத்தையும் போற்றிப் பாடியது இடம் பெற்றுள்ளது. இக்கட்டுரையில் கயமனார் இயற்கைக்காட்சியும் உவமை நலனும் அவரது பாடல்களில் எவ்வாறு கையாண்டு உள்ளார் என்பதைக் காணலாம்.

கோடைக் காற்று

சங்க இலக்கியங்களில் வாடைக்காற்றுக்கு அடுத்த நிலையில் கோடைக்காற்று இடம் பெறுவதாக எடுத்துக் கொள்ளலாம். பாலை நில வருணனையை ஒட்டியே பெரும்பாலும் கோடைகாலம் குறிப்பிடப்படுகிறது. கயமனாரின் பாடல்களில் மூன்று இடங்களில் கோடைக்காற்றுப் பற்றிய குறிப்புகள் காணப்படுகின்றன. மேற்குத் திசையிலிருந்து வீசும் கோடையால் மூங்கிலின் சிறிய இலைகள் இங்கும் அங்கும் அசைவுற்று சுழல்கின்றது (அகம் 397) இக்காட்சி அகநானூற்றுப் பாடல் ஒன்றில் காணப்படுகிறது. ஏனைய இரு இடங்களில் கோடைக்காற்றால் எழும் இனிய ஓசைகளைக் கேட்கலாம். நீரற்ற சுணையில் புகுந்து கோடைக் காற்று எழுப்பும் ஓசை பறை ஓசை போல் கேட்கின்றது. (அகம் 321) விளாம் பழம்

தோட்டில் எப்படியோ ஏற்பட்ட துளையில் புகுந்து கோடைக்காற்று எழுப்பும் ஒலி ஆயரின் புல்லாங்குழல் இசைபோல் கேட்கின்றது.

பாலைக்காட்சிகள்

பாலை நிலத்தைக் கொடிய வெப்பமும் வறட்சியும் உடையதாகக் காட்டுவது நமது புலவர்களின் மரபாக உள்ளது. கயமனாரும் வளமிழந்து வறட்சியும் வெப்பமும் மிகுந்து விளங்கும் பாலை நிலத்தைத் தம் பாடல்களில் பாடியுள்ளார். அவரது பாடல்களில் உலர்ந்து நிழலற்ற மரங்களையும் நீரற்றசுனைகளையும் பசியால் வாடும் உயிரினங்களையும் காணலாம். அவர் படைத்துள்ள தலைவனும் தலைவியும் அரிய பாலை வழியே உடன்போக்கு மேற்கொள்ளவதையும் காண்கின்றோம். மனிதர்கள் வாழ இயலாத அரிய பாலை வழியில் ஒரு யானை வாள் போலும் வரியினை உடைய புலியுடன் போரிட்டது. போரின் முடிவில் யானை முகத்தின் புள்ளிகள் சிதைந்து புண்பெற்று உதிரம் ஒழுகும் நிலையில் வலி மிகுதியால் உயர்ந்த மலை உச்சியில் இடிக்கும் இடி போல முழங்குகின்றது.

‘வாள்வரி பொருத புண்கூர் யானை

புகர் சிதை முகத்த குருதிவார

உயர்சிமை நெடுங்கோட்டு உரும்என முழங்கும்’ (அகம் : 145)

ஓமை மரத்தின் பட்டையை உரித்து தின்னும் வழக்கமுடையது யானை. அந்த மரத்தினது மேல் பட்டை புள்ளிகள் நிரம்பியதாக இருக்கும். ஓமைமரம் பிளக்கும் படி கோட்டால் குத்தியது யானை. பட்டை உரிய பெற்ற ஓமை மரம் செந்நிறமாகக் காட்சியளித்தது. அதனை மரத்தின் உச்சியில் இருந்து கண்ட ஒரு பருந்து ஊன் எனத்தவறாகக் கருதி விரைந்து பறந்து வந்து பிளவுண்ட ஓமை மரத்திலே தங்குகின்றது.

‘கடும்பகட்டு ஒருத்தல் நடுங்க குத்திப்

போழ்புண் படுத்த பொரிஅரை ஓமைப்

பெரும்பொளிச் சேய்அரை நோக்கி ஊன்செத்துக்

கருங்கால் யாத்துப் பருந்து வந்துஇறிக்கும்’ (அகம் : 397)

ஓமை மரத்தின் பட்டையைக் குத்தி அதில் உள்ள நீரை உண்ண கருதிய யானை அது உலர்ந்து இருந்ததைப் பார்த்து வருந்துகின்றது. அச்சமயம் இடிக்கும் இடியின் ஒலியைக் கேட்டு மழை பெய்யும் போலும் என்று ஆவலுடன் நிற்கும் காட்சியைக் குறுந்தொகைப் பாடலில் காணமுடிகிறது.

‘- - - முளிசினை

ஓமை குத்திய உயர்கோட்டு ஒருத்தல்

வேனிற் குன்றத்து வெவ்வரை கவாஅன்

மழைமுழங்கு கடுங்குரல் ஓர்க்கும்’ (குறுந்தொகை : 396)

வேப்பம் பழம் தின்று திளைத்து வெறுப்புற்று வவ்வால் இருப்பை மரம் நோக்கி பறக்கிறது. எதற்கு? வேம்பை விட இனிய தீச்சுவை உடைய கனியைப் பெறுவதற்காகச் செல்ல விரும்புகின்றது.

‘வேம்பின் ஒண்பழம் முனைஇ இருப்பைத்

தேம்பால் செற்ற தீம்பழன் நசைஇ

வைகுப்பனி உழந்த வாவல்’ (நற்றிணை : 279)

வேம்பின் பழத்தை வெறுத்து இருப்பையின் பழத்தை விரும்பிய வவ்வால் வெய்யப்பனி உறைப்ப இருக்கும் என்றது. தந்தையின் செல்வத்தை வெறுத்து தலைவனது செல்வத்தை விரும்பி இரவிலே சென்ற என்னுடைய புதல்வி மாமி, நாத்தனார் செறிந்திருப்ப எவ்வாறு இருக்கிறாளோ என இப்பகுதிக்கு இறைச்சி பொருள் கூறலாம்.

களிறாகிய தன் இரை தப்பியதனால் கடும் சினம் கொண்ட புலி ஒன்று முழங்குகின்றது. அதன் முழக்கம் கேட்ட பெண் யானையோ அஞ்சிக் காட்டுக்குள் ஓடுகின்றது. வேங்கையின் வெஞ்சினத்தையும் பெண் யானையின் பேரச்சத்தையும் அகநானூறு பாடல் ஒன்று அழகாகக் காட்டுகின்றது.

‘களிறுஇரை பிழைத்தலின் கயவாய் வேங்கை

காய் சினம் சிறந்து குழுமலின்

வெருகி இரும்பிடி இரியும்’ (அகம் : 221)

இருப்பை மரத்தின் வெள்ளிய பூக்களைக் கரடிக்குட்டிகள் கூட்டமாகக் கவர்ந்து உண்ணும் காட்சி, அகநானூற்று பாடல் ஒன்றில் அழகாகக் காட்டப்பட்டுள்ளது.

‘திரள்அரை இருப்பைத் தொள்ளை வான்பூக்

குருளை எண்கின் ஈர்இனம் கவரும்’ (அகம் : 257)

இன்னொரு அகப்பாடலில் உதிர்ந்து கிடக்கும் இருப்பை மலர்களை உண்ணுவதற்குத் தனது பெடையினை அழைக்கும் ஆண் மானின் குரலினைக் கேட்க முடிகிறது.

‘கதிர்க்கால் அம்பிணை உணீஇய புகல்ஏறு

குதிர்க்கால் இருப்பை வெண்பூ உண்ணாது

ஆண் குரல் விளிக்கும்’ (அகம் : 321)

கொடுமை மிகுந்த பாலை நிலத்திலும் ஆணும் பெண்ணுமாக உயிர்கள் அன்பான வாழ்க்கை நடத்துவதாகப் பாடுவதில் புலவருக்குத் தனி ஆர்வம் இருப்பதைக் காணமுடிகிறது.

கணவனும் மனைவியாகக் காதலர் நடத்தும் இல்வாழ்க்கை அன்பால் சிறந்து விளங்க வேண்டும் என்று புலவர் கொண்ட ஆசையே அவர் இவ்வாறு பாடுவதற்குக் காரணமாக அமைகின்றது. வறட்சியும் வெப்பமும் மிக்க பாலை நிலத்திலும் ஆற்றிவற்ற உயிர்கள் இன்பமாகக் கூடிவாழ்ந்து வளமான குடும்பவாழ்க்கை நடத்தும். அப்படியிருக்க ஆற்றிவுடைய இருவர் அன்பால் ஒன்றுபட்டு உயர்வது இயலாதகாரியமா என்று அறிவுறுத்தும் விதமாகவே இப்பாடல்களைப் பாடியுள்ளார்.

புறக்காட்சியில் வறட்சி காணப்பட்டாலும் அகத்தில் ஈர உணர்வு காணப்படுகின்றது. புறக்காட்சியின் வெப்பத்திற்கிடையே நெஞ்சத்தின் குளிர்ச்சியை வெளிப்படுத்துகின்றார். சுற்றுப்புற கொடுமைக்கு இடையே சிந்தையில் இனிமையை வெளிப்படுத்துகின்றார். இவ்வாறு

ஒவ்வொரு பாடல்களையும் மிக அருமையாகக் காட்சிப்படுத்தி உள்ளார். இயற்கை காட்சிகளை விரிவாக விவரிப்பது மட்டுமின்றி சிறு சிறு தொடர்கள் வாயிலாகவும் கயமனார் பாலைநிலத்தின் வறட்சியையும் வெப்பத்தையும் காட்சிப்படுத்தி உள்ளார். நீரும் நிழலும் இல்லாதது. ஆட்கள் வழங்காதது. செல்வதற்கு அரியது. மூங்கில்கள் உலர்ந்து காணப்படுவது.

மேலும் பாலைநிலக் காட்சியை அகநானூறு, குறுந்தொகை பாடல்களில் தொடர்களாக அவர் விவரிப்பதைக் காணலாம்.

‘இருநிலம் உயிருக்கும் இன்னாகானம்’ (அகம் : 275)

‘நீரில் நீள்இடை’ (அகம் : 219)

‘நீரில் அத்தத்து ஆறிடை’ (அகம் : 17)

‘ஆளில் அத்தத்து அருஞ்சுரம்’ (அகம் : 145)

‘கணமழை துறந்த கான்மயங்கு அழுவம்’ (அகம் : 397)

‘நிழல்ஆன்று அவிந்த நீர் இல் ஆறிடை’ (குறுந்தொகை : 356)

‘கழைதிரங்கு ஆறிடை’ (குறுந்தொகை : 396)

மேலும் கயமனார் பயிரினங்களையும் விலங்கினங்களையும் வருணிக்கும் போது கையாண்டுள்ள சின்ன சின்ன அடைமொழிகள் ஓவியப்பாங்கில் படிப்பதற்கு அருமையாக அமைந்துள்ளன. எடுத்துக்காட்டாக

‘கணைக்கால் காய்தல்’ (குறுந்தொகை : 9)

‘பொறி அரை விளவு’ (அகம் : 219)

‘மணிக்குரல் நொச்சி’ (நற்றிணை : 293)

‘பொரியாரை ஓமை’ (அகம் : 397)

‘வரிப்புறப் புறவு’ (நற்றிணை : 305)

‘பொன் தலை ஓதி’ (அகம் : 145)

‘உயர் கோட்டு ஒருத்தல்’ (குறுந்தொகை : 396)

‘புகர் உழை ஒருத்தல்’ (அகம் : 219)

என சில அடைமொழிகளைக் காண முடிகிறது.

பழக்க வழக்கம்

கயமனார் பாடல்களில் பழந்தமிழரின் பழக்கவழக்கங்களையும் சடங்குகளையும் காணமுடிகின்றது. உலக வழக்கை தெளிவாக முற்றும் அறிந்தவர் என்பதையும் தெரிந்து கொள்ள முடிகின்றது. பண்டைத் தமிழகத்தில் நினைத்த இடம் எல்லாம் சுற்றிதிரியும் உரிமை கன்னிபெண்களுக்கு இல்லை. அவர்கள் தாய், தந்தையரின் கடுமையான காவலுக்கு ஆளாகியுள்ளனர். இளம் பெண்கள் காலில் சிலம்பு அணியும் வழக்கம் சங்ககாலத்தில் இருந்துள்ளது. சிலம்பு கழி நோன்பு பற்றிய செய்தி நற்றிணை 279 - ஆம் பாடலில் இடம் பெற்றுள்ளது. செல்வம் மிகுந்த குடும்பத்தில் பிறந்த மகளிர் பொன்கிண்ணத்தில் பொரி கலந்த பாலை உண்டனர். அவர்கள் தம் தோழியரோடு பந்தாடி பொழுதைப் போக்கினர்.

ஆடவர்கள் தாடி வைத்திருந்தமை பற்றி குறிப்புகள் இரு பாடல்களில் காணப்படுகின்றன. திருமணகாலத்தில் பழந்தமிழர் மேற்கொண்ட சடங்குகளை அகநானூற்றுப் பாடல்கள் சிலவற்றால் அறியமுடிகிறது. தலைமகன் தலைமகள் ஆகிய இருவரது தாயாரும் ஒருவரை ஒருவர் கடிந்து கூறும் வழக்கம் இன்றைக்கு எவ்வாறு இருக்கிறதோ அதேபோன்று பண்டைக் காலத்திலும் இருந்துள்ளது என்பது நற்றிணை 293 - ஆம் பாடல் வழியாகப் புலப்படுகிறது.

வரலாற்றுக்குறிப்பு

கயமனாரின் அகநானூற்றுப்பாடல் ஒன்றில் வரலாற்றுக்குறிப்பு இடம் பெற்றுள்ளது. அன்னி என்பான் குறுக்கைப் பறந்தலையில் திதியன் என்பானை வெற்றி கொண்டு அவனது காவல் மரமாகிய புன்னையை வெட்டி வீழ்த்தினான் என்ற செய்தி அப்பாடலில் குறிப்பிடப்பட்டுள்ளது.

‘- - - - - பெருஞ்சீர்

அன்னை குறுக்கைப் பறந்தலைத் திதியன்

தொன்னிலை முழுமுதல் துமியப் பண்ணிய

நன்னர் பெல்இணர் புன்னை’ (அகம் : 145)

கயமனார் பாடல்களில் வரலாற்றுக்குறிப்பு அமைந்த இடம் இது ஒன்றே என்பது குறிப்பிடத்தக்கதாகும்.

உருவமும் உணர்வும்

இலக்கியங்களில் உவமை பொருள் புலப்படுவதற்காகவும் அணிநலத்திற்காகவும் கையாளப்படுவது வழக்கம். கயமனாரின் கைவண்ணத்திலும் ஏறக்குறைய 30 உவமைகள் இடம் பெற்றிருக்கின்றன. தலைவியின் கண், மேனி முதலியவற்றின் அழகை வர்ணிக்கும் கயமனார் அவற்றிற்கு அமைத்துள்ள உவமைகள் மிகப் பொருத்தமாக அமைந்துள்ளன. தலைவி பெண்மான் போன்ற பார்வையை உடையவள். பஞ்சு போன்ற மெல்லிய அடிகளை உடையவள். பொன் போன்ற மேனியை உடையவள். துளிரை ஒத்த மென்மையை உடையவள் என்று அகநானூறு, நற்றிணை, குறுந்தொகை ஆகிய பாடல்களில் விவரிக்கின்றார்.

‘மாண்பினை நோக்கின் மடநல்லாள்’ (அகம் : 195)

‘பொன் போல் மேனி.....

பஞ்சு மெல்லடி நடைபயிற் றும்மே’ (நற்றிணை : 324)

‘கோல்அமை குறுந்தொடி தளிர் அன்னோன்’ (குறுந்தொகை : 356)

இப்பாடல்களில் உள்ள உவமைகள் யாவும் இயற்கை பொருட்களை உவமையாகவும் மானிடப் பொலிவைப் பொருளாகவும் கொண்டவை. இயற்கை பொருட்களைப் போல் மானிட உறுப்பு நலன் அமைந்திருப்பதைக் கூறக்கூடியவை. இவற்றுக்கு நேர் எதிரான உத்தியில் அமைந்த உவமையினையும் கயமனார் ஓர் இடத்தில் கையாண்டுள்ளார்.

உப்பங்கழியில் மலர்ந்துள்ள நெய்தல் மலர்கள் வெள்ளம் மிகும் போதெல்லாம் மூழ்கி மூழ்கி தோன்றும் காட்சி குளத்தில் மூழ்கி மூழ்கி எழும் மகளிரின் கண்போல் இருப்பதாகக் குறுந்தொகை பாடல் ஒன்றில் அவர் குறிப்பிட்டுள்ளார்.

‘பாசடை நிவந்த கணைக்கால் நெய்தல்

இனமீன் இருங்கழி ஓதம் மல்குதொறும்

கயமூழ்கு மகளிர் கண்ணின் மானும்’ (குறுந்தொகை : 9)

கருமை நிறகந்தலுக்கு இடையே தோன்றும் மகளிரின் கண்கள் பச்சை நிற இலைகளுக்கு இடையே தோன்றும் நெய்தல் மலர்களுக்கு உவமையானது மிகவும் பொருத்தமாக உள்ளது. இத்தகைய சிறப்பான உவமையைக் கையாண்ட காரணத்தால் உவமையில் வரும் கயம் (குளம்) என்ற சொல்லை எடுத்துக்கொண்டு புலவருக்குக் கயமனார் என்ற பெயர் அமைந்துள்ளது குறிப்பிடத்தக்கது.

தலைவனுடைய பரத்தமை ஒழுக்கத்தை அறிந்து தனக்குள்ளே வருந்துகிறாள் தலைவி. அவள் தன் வருத்தத்தைப் பிறருக்குச் சொல்ல நாணுகின்றாள். தன் ஆருயிர்த் தோழிக்கும் சொல்லாமல் மறைத்து வாழ்கின்றாள். ஆயினும் உள்ளத்தில் ஏற்பட்ட துயரம் அதிகமாக அதனால் மெலிந்து காணப்படுகின்றாள். அழகெல்லாம் இழந்து போகின்றது. ஒரு மூடி உடைய செம்பினுள் அழகான மலர்களைப் பறித்து செம்பினுள் இட்டு மூடி வைத்தால் என்ன ஆகும்? ஒரு பயனும் இல்லாமல் வாடிப் போகும். கொடியிலும் இருக்க முடியாமல் யாரேனும் சூடி கொள்வதற்கும் பயன்படாமல் செம்பினுள் கிடந்து வாடி அழியும் மலர்களைப் போல் தலைவி தன் பெற்றோரின் செல்வமகளாகவும் வாழாமல் காதலுடைய அன்புக்குரிய துணைவியாகவும் வாழமுடியாமல் அழகு இழந்து உடல் மெலிந்து வாடுகிறாள்.

‘மாஅ யோளே

முடைமாண் செப்பின் தமிழை வைகிய

பொய்யாப் பூவின் மெய்சா யினளே

தண்ணந் துறைவன் கொடுமை

நம்முன் நாணிக் கரப்புஆ டும்மே’ (குறுந்தொகை : 9)

அகநானூற்று பாடலில் வரும் இன்னொரு தலைவியானவள் வலையைத் தொலைவில் காணும் பெண்மான் ஒன்று அதன் அருகில் அணுகாது விலகி ஓடி மறைவதைப் போல தாயின் இற்செறிப்பினைக் கண்டு அஞ்சித் தலைவனோடு உடன்போக்கு மேற்கொள்கின்றாள்.

‘வலைகாண் பிணையின் போகி ஈங்குஓர்

தொலைவுஇல் வெள்வேல் விடலையோடு

படர்தந் தோள்’ (அகம் : 7)

இயற்கையுடன் உவமை

இயற்கை பொருட்களை ஒப்பிட்டு கூறும் வகையில் அமைந்த உவமைகள் மிகவும் அழகுற காட்சிப் படுத்தப்பட்டுள்ளன. இயற்கையின் இருவேறு காட்சிகளைத் தீட்டி அவற்றிடையே ஒப்புமை நிலவுதலைக் கயமனார் மிகவும் அழகாக விளக்கியுள்ளார்.

நொச்சி மலர்களின் பூங்கொத்தானது கருமைநிறம் உடையது. அதன் இலை மயிலின் அடிபோன்றது.

‘மயில் அடி அன்ன மாக்குரல் நொச்சி’ (நற்றிணை : 305)

செந்நாயின் கூரிய வெள்ளிய பற்கள் பொன்கம்பி இழுத்தாற் போன்று தோற்றம் தருகின்றது.

‘பொன் வார் அன்ன வைவால் எயிறுச் செந்நாய்’ (அகம் : 219)

பசி மிகுந்த பெண்யானை உதைத்து பட்டை உரித்த ஓமை மரத்தின் சிவந்த அடிப்பகுதி போர் செய்த யானையின் புண்பட்ட காலை போல் தோன்றுகின்றது.

‘பொருத யானை புண்தாள் ஏய்ப்பப்

பசிப்பிடி உதைத்த ஓமைச் செவ்வரை’ (நற்றிணை : 279)

கயமனார் அகநானூற்றுப் பாடல் ஒன்றில் இலவ மலர்கள் உதிர்கின்ற காட்சிக்கு இரண்டு சிறப்பான உவமைகளைக் கூறுகின்றார். இலவ மலர்கள் காற்றால் மோதப்பட்டு ஒவ்வொன்றாய் உதிர்வது வைகறையில் வானத்து விண்மீன்கள் ஒவ்வொன்றாய் மறைவது போல் காணப்படுவதாகவும் நெய் பெய்த விளக்கின் சுடர்விழுவது போல் உள்ளதாகவும் காட்சிப் படுத்துகின்றார்.

‘நீள்அரை இலவத்து ஊழ்கழி பன்மலர்

நெய் உமிழ் சுடரில் கால்பொரச்சில்கி

வைகுறு மீனில் தோன்றும்’ (அகம் : 17)

மரக்கிளைகள் தோறும் வவ்வால்களின் மேல் பனித்துளிகள் வீழ்வது நெய் தோய்ந்த திரிச்சுடர் விழுவது போல் உள்ளது என்கிறார்.

‘வைகுபனி உழந்த வாவல் சினைதொறும்

நெய்தோய் திரியின் தண்சிதர் உறைப்ப’ (நற்றிணை : 279)

பால் பெய்யப் பெற்று நிரம்பிய பொற்கிண்ணமானது பனிநீர் நிறைந்த பகன்றையின் வெள்ளிய மலர்போல் தோற்றம் தருகின்றது.

‘பகன்றை வான்மலர் பனிநிறைந்தது போல்

பால்பெய் வள்ளம் சால்வை’ (அகம் : 219)

கேள்விச் செல்வம்

கேள்விதிறன் மிகவும் முக்கியமானது. அதன் வாயிலாக கேட்டு உணரும் ஒலிகளில் ஒப்புமை உடையவற்றை உணர்ந்து உவமைப்படுத்துவது கயமனாரின் சிறப்பியல்பாக உள்ளது. அகநானூற்றுப் பாடல் ஒன்றில் நயமான உவமையைக் கையாண்டுள்ளார். சுனை நீர் இல்லாமல் வறண்டு போனதால் தான் மேல் காற்று உள்ளே புகுந்து ஓசை எழுப்ப முடிகிறது. நீர்ற்ற சுனை என்பதை விளக்குவதற்காகப் புலவர் முன்னமே ஒரு உவமையைக் கையாண்டுள்ளார். உவமையாக வரும் பொருளும் வேற்று நிலத்து பொருள் அன்று. சுனை உள்ள மலை நிலத்து விலங்கு ஆகும். மலை போன்ற உடல் பெற்ற யானையே. வறட்சி காலத்தில் மலையில் சுனை வற்றுதல் போல் உணவு இல்லாமல் வருந்தும் யானையின்

உடலில் முதலில் வாடுவது அதனுடைய கண்கள் ஆகும். உணவு இல்லாமல் வாடிய காரணத்தால் பசுமை இல்லாமல் குழிந்துள்ள கண்களைப் போல் நீர்வற்றிய சுனையும் உள்ளே குழிந்து பசுமை இல்லாமல் காணப்படுகின்றது.

இவ்வாறு மலை நிலத்து பொருளின் மாறுதலுக்கு அதே நிலத்தில் உள்ள மற்றொன்றை உவமையாக்குவது இவருடைய சிறப்பாகும். நீரற்ற வறுமையான சுனையில் புகுந்து வரும் மேல் காற்று தெளிந்த ஓசை எழுப்பி வருகின்றது. அது மலைப்பிளவிலே சென்று எதிரொலிக்கும் போது பறை ஒலி போல் கேட்கின்றது.

‘பசித்த யானைப் பழங்கண் அன்ன

வறுஞ்சுனை முகத்த கோடைத் தெள்விளி

விசித்து வாங்கு பறையின் விடரகத்து இயம்ப’ (அகம் : 321)

மேல் காற்று எழும்புவது பற்றி இன்னொரு அகப்பாடலில் கயமனார் இவ்வாறு கூறுகின்றார். விளாம் பழத்தின் தோட்டில் எப்படியோ ஒரு துளை ஏற்பட்டிருக்க அதனுள் நுழைந்த காற்றானது ஒலி எழுப்புகின்றது. அந்த ஒலி ஆயரின் புல்லாங்குழல் இசை போல் கேட்கின்றது.

‘பொறிஅரை விளவின் புன்புற விளைபுழல்

அழல்எறி கோடை தூக்கலின் கோவலர்

குழல் என நினையும்’ (அகம் : 219)

சீள் வீடு என்னும் வண்டுகளின் ஓசை தேரில் கட்டப்பட்ட மணிகளின் ஓசை போல் உள்ளது.

‘தேர்மணி இசையில் சீள்வீடு ஆர்க்கும்’ (அகம் : 145)

முடிவுரை

சிறியது பெரியது நல்லது கெட்டது வேண்டியது வேண்டாதது இவ்வாறு எந்த வேறுபாடும் இல்லாமல் அழகு உணர்ச்சி ஒன்றே என்ற நோக்கத்தோடு மிகவும் அழகாகத் தன்னுடைய இயற்கைகாட்சிகளையும் அதன் வழியாக உவமை நலனையும் வெளிப்படுத்தி உள்ளார் கயமனார். எந்த பொருளையும் எக்காரணத்தாலும் புறக்கணிக்காமல் அதனதன் அழகில் ஈடுபடும் புலமையை சங்க இலக்கியத்தில் காணமுடிகின்றது. இவ்வாறு ஈடுபாட்டுடன் எழுதியுள்ள ஒப்புமைகள் வியந்து பாராட்டத்தக்கதாக இருக்கின்றது. சங்ககாலப் புலவர்களின் அழகுணர்ச்சியை எடுத்தியம்ப வார்த்தைகள் பத்தாது. ஆயினும் கயமனாரின் இயற்கைகாட்சிகள் மிகவும் அழகுற எடுத்துக்காட்டப்பட்டிருப்பதை அவரது கவிதைகள் வாயிலாக நாம் அறிந்து கொண்டோம். இயற்கையை அழிக்காமல் போற்றி பாதுகாப்போம்.

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கட்டுரைச் சுருக்கம்

தமிழகம் மூன்று பக்கங்களிலும் கடலால் சூழப்பட்ட நாடு. இத்தீபகற்பமும் நாற்புறமும் கடல் சூழ்ந்த தீவுகளாகிய நாடுகளைப் போன்ற இயற்கைச் சூழ்நிலைகளைப் பெற்றதாகும். எனவே, தமிழ்நாட்டு மக்கள் கடல் வாழ்வில் ஒன்றிக் கடற்பகைகளை வென்று கடல் வாணிகத்தில் ஓங்கி உயர்ந்ததில் வியப்பன்று. இன்றையத் தமிழகத்தையும், தமிழகமக்களையும் பார்க்கும்போது, இவர்களா இத்தகைய மேம்பாடு, நாகரிகம், செல்வச் செழிப்பு ஆகியவற்றைப் பெற்றிருந்தனர் என வியப்பு ஏற்படுகிறது. பழந்தமிழ் இலக்கியத்தில் இப்பெருமை பொருந்திய வரலாற்றுக் குறிப்புக்கள் பல ஆங்காங்குச் சிதறிக்கிடக்கின்றன. வெளிநாட்டு யாத்திரிகர்களின் குறிப்புக்களும் இவற்றுக்கு உதவி செய்கின்றன. இவை அனைத்தையும் கொண்டு ஆராயுங்கால், சில பகுதிகள் தமிழ் மக்கள் மிகுதியும் கடலோடு ஒன்றிய வாழ்வு உடையவர்கள் என்பதைப் புலப்படுத்துகின்றன. சில பகுதிகள் கடல் வாணிகத்தில் தமிழ்மக்கள் மிக மேம்பட்டிருந்தனர். இவற்றை ஆராய்வதே இவ்வாய்வின் நோக்கமாகும்.

முன்னுரை

கடல் வாழ்வைத் தனி வாழ்வாகக் கண்டவன் தமிழன். கடல் வாழ்வைத் தனித் திணையாக்கித் தனி இலக்கிய வளர்ச்சி கண்டவன் தமிழன். உலகிலேயே கிரேக்க உரோமர்களுடன் ஈடுகொடுத்துக் கடல்வாணிகம் செய்து, அக்கடல் வாணிகத்தில் அவரினும் மேம்பாடு கண்டவன். அதை அவர்களைக்கொண்டே சொல்ல வைத்தவன்.

சுமேரியா, பாபிலோனியா, எகிப்து, பாலஸ்தீனம், சீனா, கிழக்கிந்தியத் தீவுகள் என அவன் கடல் வாணிகத் தொடர்புக் கொண்ட நாடுகள் மிகப் பலவாகும். கடற்கொள்ளைக் கூட்டத்தாரை அடக்கி, முதன் முதலில் கடல் கடந்து ஆட்சி நிலைநாட்டிய பெருமையைத் தமிழர்களுக்குச் சேர்ப்பதில் தவறில்லை. சங்ககாலத் தமிழரின் கடல் வாணிபம் பற்றிக் இக்கட்டுரையில் சிறிது காண்போம்.

கடல் - விளக்கம்

பரந்து விரிந்து கிடக்கும் கடலை நோக்கிப் “பரவை” என்ற பெயரைக் கண்டான். செறிந்து மண்டி அடர்ந்த நீர்ப்பரப்பைக் கண்டு “புணரி” என அழைத்தான். “புணரி” என்பது செறிந்த காட்டையும் குறிக்கும் ஆதலினால், அலைபாயும் கடலை “வெண்தலைப்புணரி” என அடைமொழி கொடுத்து அழைத்தான். அது எவ்வளவு பெரிதாயினும், செறிவுமிக்கதாயினும், அதனை அடக்கிக் கடந்து, வெளிநாடுகளுடன் தொடர்புகொண்டு, வாழ்வு வளர்த்த காலத்தே இது கடத்தற்குரியது என்பான் போல் கடல் எனவும் அழைத்தான். கடல் பார்க்குங்கால் பரந்த பரவைதான் அணுகினால் செறிந்த புணரிதான், முயன்றால் கடத்தற்கியலும் கடல்தான் என இச்சொற்களே தமிழனுக்கும் கடலுக்கும் உள்ள தொடர்புகளைச் சுட்டுகின்றன எனலாம்.

கடலில் மிதக்கும் கருவிகள்

கடலைப் பற்றிய பெயர்களே அல்லாமல், கடலைக் கடத்தற்குத் தமிழன் கையாண்ட கருவிகளைப் பற்றிய பெயர்களும், அவற்றிற்கு இலக்கியங்கள் தரும் சிறு விளக்கங்களும் கூடத் தமிழன் கடலை அடக்கி ஆண்ட பெருமையை உரைக்கின்றன. அவற்றின் பெயர்களும் பலவாயினும் பலகை, மிதவை, புணை, தெப்பம், மரம், கட்டுமரம், திமில், ஓடம், படகு, அம்பி, தோணி, வங்கம், நாவாய், கலம் என்பன முதன்மையானவையாகும். இப்பெயர் வரிசையே தமிழரின் கடல்வாழ்வு, வாணிக வளர்ச்சி நிலைகளைக் காட்டும் படி வரிசைகளாகும். இவற்றுள் பலகை, மிதவை, புணை, தெப்பம், மரம் என்பன ஐந்தும் கடலில் மிதக்கும் மரங்களைக் குறிப்பன. தொடக்கநிலையில் மனிதன் இம்மரங்களைக் கடலிலே மிதக்கவிட்டுத் தான் அதிலேறி அலையோடு அலைபோலச் செல்லக் கற்றுக் கொண்டான். இதன் துணையால் மீன் பிடித்தான். நெடுந்தாரம் கடற்பயணம் செய்யவும் முயன்றான் அருகிலுள்ள தீவுகளுக்கும் சென்றுவரப் பயன்படுத்தினான்.

“பெருங்கடல் நீந்திய மரம்” (பதிற்றுப்பத்து : 76)

என்பதால் இம்மரங்கள் கடலிலே நீந்தும் காட்சியை உணர்கிறோம்.

“வெண்கிடை மிதவையர்” (பரிப்பாடல் 6 : 35)

(வெள்ளிய சடைக்கயிறுகளால் கட்டப்பட்ட மிதவையில் செல்வோர்.)

என்ற பாடல், இம்மரம் மிதப்பதால் “மிதவை” என்ற பெயர் பெற்றமையைச் சுட்டுகிறது.

பல மரங்களைக் கொண்டு கட்டி மிதக்கவிடுவதால், அது “தெப்பம்” எனப் பெயர் பெற்றது.

“புணை” என்பது பற்றுக்கோடு என்ற பொருள் தரும்.

நீரில் ஒருவன் அழிவுறாது பற்றியிருக்கும் பற்றுக்கோடு இம்மரமேயாகும். எனவே பற்றுக்கோடான மரமும் “புணை” என்று ஆயிற்று. கீழ்வரும் இலக்கியப் பகுதி இதனைத் தெளிவுபடுத்துகிறது.

“முழங்குநீர்ப் புணையென அமைந்தநின் தடமென்தோள்” (கலித்தொகை : 56)

முழங்குகின்ற நீர்ப்பரப்பிலே புணை எவ்வாறு உயிரழியாது காப்பாற்றுமோ, அதுபோல உனது அகன்ற மெல்லிய தோள்கள் எனக்கு உயிர்க் காவலாக உள்ளன.

“கரைகாணாப் பெளவத்துக் கலஞ்சிதைந் தாழ்பவன்

திரைதரப் புணைபெற்றுத் தீதின்றி உய்ந்தாங்கு” (கலித்தொகை : 134)

என்ற வரிகள் இன்னும் தெளிவாக இக்கருத்தை மெய்ப்பிக்கின்றன. “கரைகாணாத கடலிலே கப்பல் உடைய விழுந்து மூழ்கியவர், அலை கொண்டு வந்த “புணை” ஒன்றைப் பற்றிக் கொண்டு உயிர் தப்பினாற்போல என்பது இதன் பொருள்.

பலகை என்பதும் இது போன்றதொரு மரமேயாகும். ஆனால் கடலில் மிதக்குமாறு, தகடு வடிவமாக அமைந்த இப்பலகை என்பது என்ன? அது எதற்கு உதவிற்று? என்பன போன்ற கேள்விகளுக்குத் தமிழ் இலக்கியங்களிலிருந்து பெறும் விடையானது புதுமையானதாகும். சிலர் இதுவரை இதனைத் தவறாகப் புரிந்து கொண்டுள்ளனர்.

வங்கம், நாவாய், கலம் என்பன கடல் வணிகத்திற்குப் பயன்பட்ட பெரிய பாய்மரக் கப்பல்களாகத் தோன்றுகின்றன.

“கடலோடா கால்வல் நெடுந்தேர் கடலோடும்

நாவாயும் ஓடா நிலத்து” (குறள் : 496)

என்ற குறள், தரையில் ஓடும் தேருக்கு எத்துணைச் சிறப்பும், பெருமையும் உண்டோ, அத்துணைச் சிறப்பும் பெருமையும் நாவாய்க்கும் உண்டு என்பதை நமக்கு உணர்த்துகின்றது.

பெரும்பாணாற்றுப்படையில்

“.....பாற்கேழ்

வால்உளைப் புரவியொடு வடவளம் தருஉம்

நாவாய் சூழ்ந்த நளிநீர்ப் படப்பை”

பால்போலும் வெண்ணிறமான பிடரி மயிரையுடைய புரவியுடன் வடதிசைக்கண் கிடைக்கும் வளங்களைக் கொண்டு வரும் நாவாய்கள் சூழ்ந்து நிற்கின்ற செறிந்த நீர்நிலை என்ற வரிகள், இந்நாவாய்கள் மூலம் குதிரைகளும் இறக்குமதி செய்யப்பட்டன என்பதை உணர்த்துகின்றன. மதுரைக்காஞ்சி ஓரளவு நாவாயின் தோற்றத்தை உணர்த்துகிறது.

கலங்கரை விளக்கு

இக்காலத்தைப் போல அன்றும் தமிழ் மக்கள் கலங்கரை விளக்கங்களை அமைத்து, இரவு நேரத்தில் கடலில் வரும் கலங்களுக்குத் திசைகாட்டிக் கரைசேர வைக்கக் கற்றிருந்தனர். இதற்காக அவர்கள் அமைத்திருந்த மாடங்கள் வானத்தை முட்டுமாறு அமைத்த கம்பங்கள்போல உயர்ந்து இருந்தன. அதில், இரவில் தீக்கடைகோலில் கொள்ளிகளாகப் பெருநெருப்புண்டாக்கி, அதன் ஒளி மூலம் கலங்கள் கரை சேரும் திசையறியச் செய்வர்.

“வானம் ஊன்றிய மதலை போல

ஏணி சாத்திய ஏற்றருஞ் சென்னி

விண்பொர நிவந்த வேயா மாடத்து

இரவில் மாட்டிய இலங்குசுடர் ளெகிழி

உரவுநீர் அழுவத்து ஓடுகலம் கரையும்

துறை” (பெரும்பாணாற்றுப்படை 346 : 51)

வானத்தை முட்டுக்கொடுத்த ஊன்றுகோல் போல, ஏணிசாத்தப்பட்ட ஏறுவதற்கு அரிய உச்சியில், வானத்தைத் தொட்டு ஓங்கிய கூரை வேயாத மாடத்தில், இரவு நேரத்தில் கொளுத்திய விளக்கும் சுடரையுடைய கொள்ளி, கடலில் ஓடும் கலங்களை அழைக்கும் துறைமுகம். பெரியகப்பல்கள் கொணரும் பண்டங்களைப் படகுகளால் கரைசேர்க்கும் காட்சிகளை இன்று காண்கிறோம். இதுபோலக்

“கலம்தந்த பொற்பரிசம்

கழித்தோணியான் கரைசேர்க்குந்து” (புறநானூறு : 343)

என்ற வரிகளின் மூலம், பெரியகப்பல்களில் வந்த பொன்னைத் தோணிகள் மூலம் கரை சேர்த்தனர் என அறிகிறோம்.

துறைமுகங்கள்

துறைமுகம் என்பது கப்பல்கள் மற்றும் படகுகள் வந்து தங்கி செல்வதற்குரிய இடம் ஆகும். வெளிநாடுகளிலிருந்து வணிகர்கள் கொண்டு வரும் பொருட்களை ஏற்றி இறக்கி அதனை வணிகம் செய்வதற்கு ஏதுவாய் அமைக்கப்பட்ட இடமே துறைமுகம் ஆகும். பழந்தமிழகத்தில் நடைபெற்ற வணிகத்தின் பயனாய் பல துறைமுகங்கள் அக்காலத்தில் சிறப்புடன் விளங்கின.

இன்றும் துறைமுக நகரங்களில் பல்வேறு நாட்டுக் கப்பல்களும் கூடிநிற்கும் அழகிய காட்சிகளைக் காண்கிறோம். இதுபோலவே, அன்றும் தமிழகத் துறைமுகங்களில் பல்வேறு நாட்டுக் கலங்களும் நின்றன.

இதனை,

“வேறுபல் நாட்டுக் கால்தர வந்த

பல்வினை நாவாய் தோன்றும் பெருந்துறை’ (நற்றினை : 295)

இப்பாடல் வரிகள் மூலம் அறிய முடிகிறது.

ஏற்றுமதி, இறக்குமதி, வணிகம் என்ற இம்முறையைப் பொருளாதார முறைப்படி முன்பே கண்டு, நடைமுறையில் கையாண்ட பெருமை தமிழனைச் சாரும். பட்டினப்பாலையில்,

“நீரினின்றும் நிலத்துஏற்றவும்

நிலத்தினின்று நீர்ப்பரப்பவும்

அளந்தறியாப் பலபண்டம்

வரம்பு அறியாமை வந்தீண்டி

அருங்கடிப் பெருங்காப்பின்

வலியுடை வல்லணங்கின் நோன்

புலிபொறித்துப் புறம்போக்கி”

நீரில் வந்தவற்றை நிலத்தில் ஏற்றியும், நிலத்தில் வந்தவற்றை நீரில் உள்ள கலங்களில் ஏற்றியும், அளந்தறிய முடியாத பலவாகிய பண்டங்களை வரம்பின்றிக் குவித்து, காத்து, வலிய புலிச் சின்னத்தைப் பொறித்து வெளியே அனுப்பி. என்ற வரிகள் ஏற்றுமதி இறக்குமதி வணிகத்தைப் பற்றியும் கூறுகிறது.

எயிற்பட்டினம் என்ற துறைமுகப்பட்டினத்தைப் பற்றியும் அங்கு இருந்த கலங்கரை விளக்கத்தைப் பற்றியும் சங்க இலக்கியத்தில்

“மணிநீர் வைப்பு மதிலொடு பெயரிய

பனிநீர் படுவின் பட்டினம்”

நீலமணி போன்ற கழிகள் சூழ்ந்த ஊர்களையுடையதும் மதிலுடன் கூடிய பெயரைப் பெற்றதும் ஆகிய எயிற்பட்டினம் என்று குறிக்கப்படுகிறது. மூன்று புறமும் கடல் சூழ்ந்த

பழந்தமிழகம் பல்வேறு துறைமுகப்பட்டினங்களைப் பெற்றுத் தன் காலத்து நாகரீகமிக்க நாடுகள் அனைத்துடனும் வணிகத் தொடர்பு கொண்டு திகழ்ந்ததைக் காணமுடிகிறது.

முசிறி

சேர நாட்டுக் கடற்கரையில் வஞ்சிமா நகரத்திற்கு மேற்கே கள்ளிப் பேரியாறு கலந்த இடத்தில் அதன் வடகரை மேல் கடற்கரையையொட்டி முசிறித் துறைமுகமும், முசிறிப் பட்டினமும் இருந்தன என்பதனை,

“யவனர்தந்த வினைமாண் நன்கலம்

பொன்னொடு வந்து கறியொடு பெயரும்

வளங்கெழி முசிறி” - (அகம்.149, வரி.9 - 11)

என்ற வரிகள் மூலம் அறியலாம் முசிறி என்னும் சேரநாட்டுத் துறைமுகப் பட்டினத்தில், யவனர்களின் கப்பல்கள் பொன்னைக் கொடுத்து, அதற்கு விலையாகக் கறியை ஏற்றிக்கொண்டு போனதைப் புலவர் தாயங்கண்ணனார் கூறுகிறார். கறி என்பது சங்ககாலத்தில் மிளகைக் குறிக்கும் சொல்லாகும்.

காவிரிப்பூம்பட்டினம்

சோழர்களின் தலைநகராகவும், துறைமுகப்பட்டினமாகவும் இருந்தது காவிரிப்பூம்பட்டினம். இத்துறைமுகம் காவிரி ஆறு வங்கக்கடலுள் கலக்கின்ற புகார் முகத்தின் வடகரையில் அமைந்திருந்தது. இது பூம்புகார் என்ற பெயரில் அழைக்கப்படுகிறது. கடல்கோள் காரணமாக, இந்நகரம் அழிந்துபோனது. துறைமுகத்தில் வந்து தங்கிய கப்பல்கள் (நாவாய்கள் - மரக்கலங்கள்) நிற்பது, யானைப்பந்தியில் நிற்கும் யானைகள் அசைந்து கொண்டிருப்பதைப் போன்று இருந்தன என்பதைக் கீழ்கண்ட பட்டினப்பாலை வரிகளால் அறியலாம்.

“வெளியில் இளக்கும் களிறு போலத்

தீம்புகார்த் திரை முன்துறைத்

தூங்கு நாவாய் துவன்றிருக்கை

மிசைக் கூம்பின் நசைக் கொடியும்” - (பட்டினம்.172 - 175)

கொற்கை

பாண்டியர்களின் தலைசிறந்த துறைமுகமாகக் கொற்கை திகழ்ந்தது. தாமிரபரணியின் சங்கமுகத்தில் அமைந்த துறைமுகநகரம் கொற்கை. “மருங்கூர்ப் பட்டினத்திற்கு தெற்கே கொற்கைக் குடாக்கடலும், அதன் மேற்குக்கரையில் கொற்கைத் துறைமுகப்பட்டினமும்” இருந்தன என்பதனை,

“கொற்கை முள்துறை இலங்கு முத்து உறைக்கும் - (ஐங்குறுநூறு : 185)

“ஈண்டுநீர் முத்துப்படு பரப்பின் கொற்கை முன்றுறை” - (நற்றிணை : 23)

என்ற ஐங்குறுநூறு, நற்றிணை வரிகள் கொற்கைத் துறைமுகத்தின் சிறப்பினை அழகாக எடுத்துரைக்கின்றன.

கொற்கை முத்தின் சிறப்பினைப் பல்வேறு பாடல்கள் எடுத்துரைக்கின்றன.

“மறப்போர்ப் பாண்டியர் அறத்தின் காக்கும்
கொற்கை அறம்பெரும் துறைமுத்தின் அன்ன” - (அகம்.27, வரி.8 - 9)

“புகழ்மலி சிறப்பின் கொற்கை முன்துறை

அவிர்கதிர் முத்தமொடு வலம்புரி சொரிந்து” - (அகம்.130,வரி.9 - 11)

கடல் கடந்த நாடுகளிலிருந்து அகிற்கட்டை, சந்தனக்கட்டை, பட்டுத்துணி, சாதிக்காய், இலவங்கம், குங்குமப்பூ, கற்பூரம் முதலான வாசனைப் பொருட்களை ஏற்றி வந்த நாவாய்கள் கொண்டல் காற்றின் உதவியினால் தொண்டித் துறைமுகத்தை வந்தடைந்ததையும், இறக்குமதியான அந்தப் பொருட்களைத் தொண்டியிலிருந்து பாண்டியனின் தலைநகரான மதுரைக்கு அனுப்பப்பட்டதையும் கீழ்க்கண்ட சிலப்பதிகார பாடல் வரிகள் அழகாக எடுத்துரைக்கின்றன.

“ஓங்கு இரும் பரப்பின்

வங்க ஈட்டத்துத் தொண்டியோர் இட்ட

அகிலும், துகிலும், ஆரமும், வாசமும்,

தொகுகருப் பூரமும் சுமந்துடன் வந்த

கொண்டலொடு புகுந்து கோமகன் கூடல்

வெங்கண் நெடுவேள் வில்விழாக் காணும்

பங்குனிமுயக்கத்துப் பனி அரசு யாண்டுளன்?” - (சிலம்பு. ஊர்காண். வரி. 106 - 112)

மருங்கூரப்பட்டினம்

மருங்கூரப்பட்டினம் “மருங்கை” என்றும் அழைக்கப்பட்டது. பாண்டிய நாட்டுத் (பாண்டியநாட்டின் கிழக்குக் கரையிலிருந்த) துறைமுகப்பட்டினமாகும். பசும்பூண் வழி என்ற பாண்டிய மன்னனுக்குரிய செழுமையான, தலைசிறந்த பட்டினமான இதனை,

“பசும் பூண் வழி மருங்கை” - (நற்றிணை. 358, பா. வரி. 10)

என்னும் பாடல் வரியின் வழி அறியலாம்.

செல்வ வளம் பொருந்திய மாடமாளிகைகளை உடையது இப்பட்டினம் என்பதை,

“திருவுடை வயில் நகர்.....” - (நற்றிணை. 258, பா. வரி. 4)

என்ற பாடல் வரி உணர்த்துகின்றது. எப்போதும் மக்கள் கூட்டத்துடன் காணப்படும். பாண்டிய நாட்டு புலவரான நக்கீரர், காயல்களும் (உப்பங்கழிகள்) தோட்டங்களும் உள்ள இத்துறைமுகத்தின் கடைத்தெரு செல்வ வளம் கொழித்திருந்தது என்பதைப் பின்வரும் பாடலடிகள் மூலம் அழகுற எடுத்துரைக்கின்றார்.

“விழுநிதி தஞ்சம் வீறுபெறு திருநகர்

இருங்கழிப் படப்பை மருங்கூர்ப் பட்டினத்து

எல்லுமிழ் ஆணவம்” - (அகம். 227, வரி. 19 - 21)

பொழுது இறங்கும் நேரத்தில் அகன்ற கடைத்தெருவில் நிழலிலே குவித்து வைத்திருந்த பச்சை இறாமீனைக் கவர்ந்துண்ணும் காக்கை, கடலில் செல்லாது கடலில்

தங்கி நிற்கும் வங்கக் கப்பலின் பாய்மர உச்சியில் சென்று தங்கும் என்று மருங்கூர்ப்பட்டினத் துறைமுகத்தைப் பற்றி நக்கீரர் தமது நற்றிணையில் நயமுடன் உரைத்துள்ளார்.

“அகல் அங்காடி அசைநிழல் குவித்த

பச்சிறாக் கவர்ந்த பசங்கட் காக்கை

தூங்கல் வங்கத்துக் கூம்பில் சேக்கும்

மருங்கூர்ப் பட்டினத்து அன்ன” - (நற். 258, வரி. 7 - 10)

மாந்தை

சேரநாட்டுத் துறைமுகப்பட்டணமாக அறியப்படுகின்ற மாந்தை “துறைகெழுமாந்தை”, “கடல்செழுமாந்தை” என்று கூறப்படுகின்றது. “மாந்தை” என்றும் கூறப்பட்டது. மாந்தைப் பட்டினத்தில் இமயவரம்பன் நெடுஞ்சேரலாதன் பொன், வைரம் விலையுயர்ந்த மணிகள் முதலான பெருஞ்செல்வத்தை ஆம்பல் கணக்கில் (ஆம்பல் என்பது கணிதத்தில் பெருந்தொகையைக் குறிக்கும் சொல்லாகும்) புதைத்து வைத்திருந்தான் என்றும், மாற்றாரிடம் திறையை வாங்கியதாகவும் மாமூலனார் கூறுகிறார்.

“வலம்படு முரசிற் சேரலாதன்

முந்நீரோட்டிக் கடம்பறுத் திமயத்து

முன்னோர் மருள வணங்குவிற் பொறித்து

நன்னகர் மாந்தை முற்றத்து ஒன்னர்

பணிதிறை தந்த பாடுசால் நன்கலம்

பொன் செய்பாவை வயிரமொடு ஆம்பல்

ஒன்றுவாய் நிறையக் குவைஇ அன்றவண்

நிலந்தினத் துறந்த நிதியம்” - (அகம். 127, வரி. 3 - 10)

இந்த பெருஞ்சேரலாதன் கடற்கொள்ளைக்காரக் குறும்பரையை அடக்கியவன். இத்துறைமுகத்தைப் பற்றிய வேறு குறிப்புகள் ஏதும் இல்லை.

கடற்கோள்

கடலை அடக்கியாண்டு, பிறநாட்டுக் கரையகங்களை அடைந்து வாணிக வளத்தைப் பெருக்கிய தமிழன் மிக உயர்ந்த இன்பச் செருக்கில் ஆழ்ந்திருந்தான். அவனுடைய செருக்கினைத் தகர்ப்பதற்கோ என்னவோ, கடல்கோள்கள் பல ஏற்பட்டு, அவன் தனது நாட்டின் கடலோரப் பகுதிகளை இழக்க நேரிட்டது. சேர நாட்டில் முசிறியும், தொண்டியும். வஞ்சியும் பெருமையுடன் இருந்தமையைத் தமிழ் இலக்கியங்களிலும், பிறநாட்டு யாத்திரிகர்களின் குறிப்புகளிலும் காண்கிறோம் ஆனால் அந்நகரங்களை இன்று காணும் நிலை இல்லை. பாண்டியனின் கொற்கையும் சோழனின் காவிரிப்பூம்பட்டினமும் இங்ஙனமே கடலுக்கு இரையாகி மறைந்தன.

பொங்கி எழுந்து அழிக்க வந்த கடலைக்கண்டு, இயற்கையின் பெருஞ்சீற்றத்திற்குத் தமிழன் அஞ்சினான். இந்த அச்சமே கடல் வாணிகத்தில் வளர்ந்து வந்த தமிழனின் முன்னேற்றத்தைத் தடைப்படுத்திவிட்டது. இன்றேல், இன்றைய உலக நாகரிகத்தின்,

வேராகமட்டுமன்றி, அதன் கிளையாகவும் இலையாகவும் பூவாகவும் காய் கனியாகவும் அவனது நாகரிகமே பெருகியிருக்கும்.

கடலைக் கண்டு தமிழன் அஞ்சவில்லை - அதன் சீற்றத்துக்கு அஞ்சினான். கடலை ஒரு தெய்வமாகவே கருதி வழிபட்டான்.

“முந்நீர் விழவின் நெடியோன்” (புறநானூறு : 6)

என்ற பாடல் வரி கடற்செலவு என்பது கடல்விழா நடத்திய நெடியோன் என்னும் பாண்டியன் கடலுக்கு விழாவெடுத்த செய்தியை இயம்புகிறது.

முடிவுரை

சங்ககாலத் தமிழரின் மேம்பாடு, நாகரிகம், செல்வச்செழிப்பு மக்களின் மிகுதியும் கடலோடு ஒன்றிய கடல் வாணிகத்தில் வாழ்வு வாழ்ந்தவர்கள் என்பதைப் புலப்படுத்துகின்றன. சங்க இலக்கியங்களில் பல துறைமுகங்கள் பற்றிய செய்திகள் பாடல் வரிகள் மூலம் எடுத்துரைக்கப்பட்டுள்ளன. அவை தற்போது பரவலாக பலராலும் அறியப்படாமலே உள்ளன. சங்ககாலத்தில் கடல் வாணிகத்தில் தமிழ் மக்கள் மிக மேம்பட்டிருந்தமையைத் மேலே கூறிய செய்திகள் தெளிவுபடுத்துகின்றன.

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தமிழ்க் கவிதைகளில் பெண்கள்

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கட்டுரைச் சுருக்கம்

பல்லாயிரக் கணக்கான ஆண்டுகளாகப் பெண்களின் வாழ்வுரிமை அடிமை நிலையாகவே இருந்து வருகிறது. எனவே பெண்விடுதலை என்னும் கருத்தோட்டங்களின் தொடர்ச்சியை எடுத்துரைப்பது இக்கட்டுரையின் நோக்கமாகும். மனித உயிரினத்தில் சரிபாதியாகத் திகழும் ஆணும் பெண்ணும் இச்சமுதாயத்தில் சமஉரிமை பெற்றிருக்கவில்லை. இவ்வுற்றத்தாழ்வுகள் கல்வி, சமூகம், அரசியல், பொருளாதாரம் அனைத்திலும் ஆண் சமூகத்தை முன்னுக்குத் தள்ளி பெண்சமூகத்தைக் குறிப்பாகத் தலித் பெண்களைப் பின்னுக்குத் தள்ளியதை நம்மால் மறுக்கமுடியாது. தலித் பெண்களின் துன்பம், உரிமை மறுக்கப்படுதல், தலித் பெண்கள் தாழ்த்தப்படுதல் போன்றவற்றைத் தலித் கவிஞர்களின் கவி வழி விளக்குகிறது இக்கட்டுரை.

முன்னுரை

பரந்து விரிந்த சமூக அமைப்பில் கடைநிலை வாழ்க்கை வாழும் மக்களின் நிலை மிகவும் இரங்கத்தக்கது. சாதிய அமைப்பும், அதிகாரமும் கொண்ட இச்சமூகத்தில் தங்கள் வாழ்வுரிமைகளை இழந்து வருந்துவோர் பலர். ஒருபக்கம் தங்கள் இனத்தைச் சுரண்டும் மேல் சாதியினர். இன்னொரு பக்கம் சமூகக் கட்டுப்பாடுகளைச் சாதியின் பெயரால் கடைநிலை மக்கள் மீது திணித்தல். இத்திணிப்புகளால் மீண்டும் மீண்டும் பாதிக்கப்படுவது பெண்கள் தான். சாதிக் கட்டுப்பாடுகளும் சாதியின் அடக்கு முறைகளும் பெண்களின் வாழ்க்கையைப் ஒரு போர்க்களமாக மாற்றுகிறது. இப்பெண்சமூகத்தில் மிகமோசமாக சமூகத்தால் மட்டுமல்லாமல் குடும்பத்திற்குள் நசுக்கப்படுபவர்கள் தலித் பெண்கள்தான். தலித் பெண்கள் உயர்சாதி ஆணுக்கும் தன் இனத்தின் ஆணுக்கும் கட்டுப்பட்டு நடக்கவேண்டியதாய் இருக்கிறது. தமிழ்க் கவிதைகளின் மூலம் தலித் பெண்களின் பிரச்சனைகள், உணர்வுகள், துன்பங்கள் போன்றவற்றை இக்கட்டுரை விளக்குகிறது.

காலந்தோறும் தலித் பெண்களின் வாழ்க்கை

தலித் மக்களின் வாழ்க்கை வரலாறு பல்லாண்டுகால மனிதத் தன்மையற்ற சமூகக் கலாச்சார மற்றும் அரசியல் பொருளியல் ஒடுக்குமுறையை உள்ளடக்கியது. ஊர்ப்பொதுக் குளத்தில் குடிநீர் எடுப்பதற்கும் கோவிலுக்குள் நுழைவதற்கும் அனுமதி மறுக்கப்பட்டன. ஆடவர் தலையில் தலைப்பாகை அணியக் கூடாது. காலில் செருப்பு அணியவும், கல்வி கற்கவும் அரசியல் செய்யவும் அதிகாரம் இல்லை. பெண்கள் மேலாடை அணியக் கூடாது. மனிதன் மாண்புடனும் சுயமரியாதையுடனும் வாழ வழியில்லாமல் இருந்தது. தலித் பெண்களுக்கு எதிரான அடக்குமுறைகளும் வன்முறைகளும் நாளுக்கு நாள் வளர்ந்து வருகின்றன. ஒருபுறம் குடும்பச் சூழல் மறுபுறம் ஆதிக்க, அதிகார வர்க்கத்தினரின் காமவெறிக்கும், வன்புணர்ச்சிக்கும் பெண்கள் ஆளாகி வருகின்றனர். இவ்வாறாக

காலங்காலமாகத் தலித் பெண்கள் மிருகங்களிலும் இழிவானப் பொருளாக ஒடுக்கப்பட்டு அநீதிகளுக்கும், கொடுமைகளுக்கும் உட்படுத்தப்பட்டு வருகின்றனர்.

வன்கொடுமைகள்

அன்றும் இன்றும் தலித் பெண்கள் மட்டுமல்லாமல் பெண் சமூகம் சந்திக்கும் வன்கொடுமைகள் பற்பல. உடல்ரீதியான தாக்குதல், சொற்களால் அவமதித்தல், பாலியல் ஒடுக்குதல், கற்பழிப்பு, விபச்சாரத்திற்கு வற்புறுத்துதல், கடத்திச் சென்று வன்முறையாக உடல் உறுப்புகளைச் சிதைத்தல் இப்படி சொல்லிக்கொண்டே போகலாம். இப்பெண் வன்கொடுமைகள் பொதுஇடங்களில், பணியிடங்களில், காவல் கண்காணிப்பு நிறுவனங்களில், வயல்வெளிகளில், கிராமப்புறவெளிகளில், ரயில்களில், பேருந்துநிலையங்களில் ஏன் கழிப்பிடங்களில் கூட நடத்தப்படுகின்றன. திருமணம் செய்துகொள்வதாக உறுதியளித்து பாலியல் சுரண்டலுக்கு ஆட்படுத்துவதும், பின்னர் கைவிட்டு விலகுவதும், அதன் தொடர்ச்சியாகக் கொலை செய்வதும் கூட சாதாரணமாக நடக்கின்றன.

“சிட்டுகள் சுதந்திரமாய் பறக்கும் முன்னே

சிறகுகள் சிதைக்கப்பட்டதோ?

மொட்டுகள் மணம் வீசி மலரும் முன்னே

பலவந்தமாய் பறிக்கப்பட்டதோ?

தளிர்கள் தானாய் துளிர்க்கும் முன்னே

வெட்டி வீசப்பட்டதோ?

எஞ்சிய வாழ்வெல்லாம் இப்பிஞ்சுகளை

இழந்த பெற்றோர் மனம்

விறகாய் தீயில் வீசப்பட்டதோ?

நதிகளும், நாடும் பெண் எனப் போற்றும்

திருநாட்டில் இக்கொடுமைகள்

கூச்சமின்றி அரங்கேற்றப்பட்டதோ”

கவிஞர் இரா. இராம்கியின் கவிதை வெறும் கவிதை வரிகள் மட்டுமல்ல இச்சமூகத்தை நம் கண்முன்னே காட்டும் கண்ணீர் வரிகளாக இருக்கின்றன.

அவமானங்கள்

சமூகத்தில் விளிம்பு நிலையில் வாழும் பெண்கள் பல்வேறு சவால்களைச் சந்திக்க வேண்டியுள்ளது. ஏழைகள், படிக்காதவர்கள், சமூகரீதியாக ஓரங்கட்டப்பட்டவர்கள், உரிமைகளுக்காகப் போராடுபவர்கள் என்பன அச்சவால்களுள் குறிப்பிடத்தக்கன. இதனால் இவர்கள் தங்கள் வாழ்க்கைப் பயணத்தில் பல அவமானங்களைச் சந்திக்கின்றனர்.

“செத்துப்போன மட்டைத் தோலுரிக்கும் போது

காகம் விரட்டு வேன்

வெகுநேரம் நின்று வாங்கிய ஊர்ச் சோற்றைத்

தின்று விட்டு சுடுசோறெனப் பெருமை பேசுவேன்

.....

அப்பாவின் தொழிலும் ஆண்டு வருமானமும்
சொல்ல முடியாமல் வாத்தியாரிடம் அடிவாங்குவேன்
தோழிகளற்ற பின் வரிசையிலமர்ந்து
யாருக்கும் தெரியாமல் அழுவேன்”

தலித் என்று சொல்ல முடியாமல் தான் அனுபவிக்கும் அவமானங்களைக் கவிதையாக வெளிப்படுத்தியவர் தன்னைத் தலித் என்பதைப் பெருமையாக வெளிப்படுத்துகிறார்.

“இப்போது யாரேனும் கேட்க நேர்ந்தால்
பளிச்சென்று சொல்லி விடுகிறேன்
பறச்சி என்று”

தன்னம்பிக்கை

வாழ்க்கையில் வெற்றி பெற்ற மனிதர்களின் வாழ்க்கையைப் புரட்டிப் பார்த்தால் அவர்களுக்கு மூலதனமாக இருப்பது தன்னம்பிக்கை அவ்வகையில் கவிஞர் சுகிர்தராணி மிகவும் தன்னம்பிக்கையும் துணிச்சலும் உடையவர். இந்தச் சமுதாயம் சேரியைப் பார்க்கும் பார்வை தாழ்ந்ததாக இருந்தாலும் சேரியில் பிறந்து வளர்ந்து வாழ்ந்த பெண் தன் இருப்பிடத்தை உயர்வாகப் பார்க்கும் நிலையைப் பின்வரும் கவிதை வரிகள் வெளிப்படுத்துகின்றன.

“மெல்லிய புலால் நாற்றம் வீசுகின்ற
நானும் தசைகளை முற்றாகப்
பிய்த்தெடுத்த எலும்புகள் தொங்கும் என்வீடும்
கொட்டாங்குச்சியில் தோலைக்கடி பறையொலி
பழகும் விடலைகள் நிறைந்த
என் தெருவும்
ஊரின் கடைசியில் இருப்பதாக
நினைத்துக் கொண்டிருக்கிறார்கள்
நான் சொல்லிக் கொண்டிருக்கிறேன்
முதலில் இருப்பதாய்”

தன் வீடு குறித்த வர்ணனையிலும் ‘தசைகளை முற்றாகப் பிய்த்தெடுத்த எலும்புகள் தொங்கும் என் வீடு’ என்று கூறுவதன் மூலமும் அவர் தன் அடையாளங்களை மறைக்காமல் வெளிப்படுத்தியுள்ளதை தெரிந்து கொள்ள முடிகின்றது. ‘சேரி’ ஊரின் கடைசியில் இருப்பதாக எல்லோரும் சொல்கிறார்கள் ஆனால் அது அவர் பார்வைக்கு முதலில் இருப்பதாகக் கூறுவதிலிருந்து அவரின் தன்னம்பிக்கையை உணர்ந்து கொள்ள முடிகின்றது.

அடக்குமுறைக்கு எதிரான குரல்

ஆதிக்க மலைகளாலும் அதிகார அலைகளாலும் நசுக்கப்படுகிற, ஒதுக்கப்படுகிற பெண் இனத்தின் உரிமைக்காகவும் வாழ்விற்காகவும் போராடும் போராளிகள் பெண்கள்

மட்டுமல்ல. கவிஞர் இன்குலாப் பெண்ணியக் கருத்துகளை முன்னெடுத்து, பெண்களுக்கு எதிரான அனைத்து அடக்குமுறைகளுக்காகவும் எதிராக ஓங்கி குரல் கொடுத்தவர்.

“கிளிகள் என்றும் ஆடும்
மயில்கள் என்றும் நீங்கள்
கேட்ட வருணனை கொஞ்சங்களோ?
..... ஓ
கிளிகளே! உங்களின்
சிறகெங்கே?”

என்று கேட்பதோடு நில்லாமல்,

“இறக்கை வெட்டிய கிளிகளாய் - நீங்கள்
எத்தனை காலம் இக் கூண்டுக்குள்ளே
பறக்கத் துடிக்கும் பறவைகளே - இங்குப்
பரந்து கிடக்குது பிரபஞ்சம்”

என்று பெண்களுக்குத் திசைகளைக் காட்டுகிறார். மேலும் பெண்கள் விழிப்படைய வேண்டும் என்பதற்காக,

“தாமரைப் பூவில் சரசுவதியாய்.....
பெண்ணை
தாங்கள் மதிப்பதாய்க் கதை அளப்பார்
தாமரைப் பூவினில் வாழாத - சேரி
சரசுகள் எத்தனைபேர் படித்தார்?”

என்று தனது கோபக்கனலை வெளிப்படுத்துகிறார். அன்றாடம் உழைக்கும் செயலுக்குப் ‘பறபாடு’ என்றும் கையிலிருப்பதை மணிக்கட்டோடு பறித்துச் சென்றால் ‘பறநாய்’ என்ற எதிர்நிலையிலும் விவரிப்பார். இவ்வாறு சகலத்திற்கும் ‘பற’ என்ற சொல்லைக் கீழ்நிலையில் பயன்படுத்துகிறார்கள்.

“சொல்லுகின்றீர்கள் முதுகு விரியக் காய்ந்தால்
அதன்பெயர் பறவெயில் உலரும் புழுத்த
தானியத்தை அலகு கொத்தி விரையும்
அது பறக்காகம்.....
நிலத்தை உழுது வியர்வை விதைத்தால்
அது பறப்பாடு”

இவ்வாறு சகலத்திற்கும் ‘பற’ என்ற சொல்லைப் பயன்படும் மக்கள் கடவுளுக்கு மட்டும் ஏன் ‘பறக்கடவுள்’ என்ற பட்டத்தை வழங்கவில்லை இதனை,

“சகலத்திற்கும் இப்படியே பெயர் என்றால்
இரத்த வெறியில் திளைக்கும் எது அந்தப் பறக்கடவுள்”

சாதிய, இனத்தின் அடக்குமுறைக்கு எதிராக இதனைப் பதிவு செய்கிறார்.

முடிவுரை

சமுதாயத்தில் தலைமுறை தலைமுறையாகப் பொருளாதார ரீதியாகவும், சமுதாய அமைப்பு ரீதியாகவும், கல்வி மற்றும் ஒடுக்கு முறையினாலும் இன்னலுறும் பெண்களின் வாழ்வியல் போராட்டங்களைத் தமிழ்க் கவிதைகள் அழகுற வெளிப்படுத்தியுள்ளன. இத்தமிழ்க் கவிதைகள் அடித்தட்டு மக்களின் பண்பாட்டு அடையாளங்களை மீட்டெடுப்பது மட்டுமல்லாமல் அவர்களின் வாழ்க்கைத் தரமும் உயர்வதற்கான விழிப்புணர்வையும் கொடுக்கிறது.

துணை நூற்பட்டியல்

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