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GRF

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PREFACE

It is with great pleasure that we introduce the International Multidisciplinary Journal, Global Research Frontier (GRF). As a premier platform for scholarly research and innovation, GRF aims to facilitate the dissemination of cutting-edge knowledge and ideas across various disciplines.

In today's rapidly changing world, the need for interdisciplinary collaboration and knowledge sharing has never been more pressing. GRF seeks to address this need by providing a forum for researchers, scholars and practitioners to share their research findings, innovative solutions, and expert insights.

Our journal is committed to publishing high-quality, peer-reviewed articles that advance the frontiers of knowledge in various fields, including science, technology, engineering, arts and mathematics (STEAM). We also welcome submissions that explore the intersections and applications of these disciplines in addressing real-world challenges.

As we embark on this exciting journey, we express our gratitude to our editorial board, reviewers and authors for their invaluable contributions. We look forward to working with scholars and researchers from around the world to advance the global research frontier.

Dr.Atul Kumar Tiwari
Associate Professor
School of Environmental Biology
A.P.S.University, Rewa (M.P.), India

EDITORIAL

Dr. Atul Kumar Tiwari
Chief Editor
GRF

The "Global Research Frontier" (GRF) is a beacon of innovation and progress, bridging the gap between scientific research and societal development. As a premier international journal, GRF will be instrumental in shaping the trajectory of scientific inquiry and its applications, ultimately impacting society in profound ways.

One of the most significant impacts of GRF is the realm of knowledge dissemination. By publishing cutting-edge research in various scientific disciplines, GRF has facilitated the exchange of ideas and information among researchers, policymakers, and practitioners. This has enabled the translation of scientific discoveries into practical solutions, addressing some of the most pressing challenges facing society today, such as climate change, healthcare, and sustainable development.

The Global Research Frontier (GRF) will play a pivotal role in advancing scientific development globally. As an international, peer-reviewed journal, GRF provides a platform for researchers, scientists, and scholars to share their groundbreaking findings, innovative ideas, and cutting-edge research in various scientific disciplines.

One of the primary roles of GRF is to facilitate the dissemination of knowledge and promote collaboration among researchers worldwide. By publishing high-quality, original research articles, review papers, and case studies, GRF will enables scientists to stay updated on the latest developments in their fields, fostering a culture of innovation and progress. This, in turn, it will accelerates the pace of scientific discovery, driving breakthroughs in fields such as medicine, technology, and environmental science.

GRF will also serves as a catalyst for interdisciplinary research, encouraging scientists to explore new frontiers and push the boundaries of human knowledge. By providing a platform for researchers from diverse backgrounds and disciplines to share their work, GRF also facilitates the exchange of ideas, methodologies, and expertise, lead to the development of novel solutions to complex problems.

Furthermore, GRF will play a crucial role in promoting evidence-based decision-making and policy development. By publishing rigorous, peer-reviewed research, this journal provides policymakers, practitioners, and stakeholders with reliable, up-to-date information, enabling them to make informed decisions that drive positive change.

In addition, this journal will contribute to the development of the next generation of scientists and researchers by providing a platform for early-career researchers to publish their work. GRF also help to nurture their talent, build their confidence, and establish their reputation in the scientific community.

In conclusion, the Global Research Frontier will play a vital role in advancing scientific development globally. By facilitating the dissemination of knowledge, promoting collaboration and interdisciplinary research, supporting evidence-based decision-making, and nurturing the next generation of scientists, GRF will contribute significantly to the progress of science and the betterment of society. As a leading international journal, GRF will continue to shape the future of scientific research, driving innovation, and improving lives worldwide.

Exploring the Efficacy of Commercial Neem Formulations in Integrated Pest Management: A Laboratory Study on Tobacco Caterpillar Control

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Abstract

The shift towards greener agriculture, focusing on ecological methods in pest control, is driving further research into alternative pesticide compounds, moving away from synthetic ones. This has led to increased exploration of plant-based solutions, with neem (Azadirachtaindica) emerging as a leading natural pesticide. However, concerns persist about its environmental impact. This study centers on understanding neem's effects on beneficial insects and the environment, aiming to integrate it into Pest Management strategies. The research evaluated the effectiveness of various commercial neem formulations - Bioneem, Econeem, Nimbicidine, Neemarin, and Nemazal - at concentrations of 0.5%, 1.0%, and 1.5% against tobacco caterpillar larvae (Spodopteralitura Fab) in the laboratory. Results showed that Neemarin, at a 1.5% concentration, achieved 90% larval mortality after 72 hours. This was followed by 83.33% for Neemazal, 20.00% for Econcern, and 63.33% for Bioneem, and 53.33% for Nimbicidine after 168 hours of treatment.

Introduction:

Cauliflower (Brassica oleracea L.) stands as a cherished staple among winter vegetables, thriving in cold and moist climates, albeit being less resilient than cabbage. Characterized by a compact stem adorned with a cluster of leaves and a branched taproot system, cauliflower emerges as a veritable reservoir of essential nutrients, boasting ample reserves of Vitamin A, Calcium, Phosphorus, Potassium, along with moisture, carbohydrates, proteins, fats, fiber, and iron. Originating from southern Europe's Mediterranean enclave, cauliflower found its way to India in 1822, courtesy of England. Today, major cauliflower production centers dot Bihar, Uttar Pradesh, Assam, Haryana, Orissa, West Bengal, and Maharashtra. However, the journey to cauliflower harvest is fraught with challenges posed by various insect pests. Among the notable adversaries are the Cauliflower aphid (Bevicorynebrassicae L.), Cabbage butterfly (Pierisbrassicae L), Diamondback moth (Plutellaxylostella L), and painted bug (Bagradacruciferaum. Kirk). Cauliflower's cultivation isn't confined to specific soil types; nevertheless, it flourishes best in nutrient-rich, well-drained soil with optimal moisture retention. The ideal soil pH for cauliflower growth hovers between 6.0 to 6.5, as noted by Girish et al. in 2010. Studies by Bhalia and Gupta (2003), and Meghanaet al.,(2018) have delved into the realm of cauliflower's pests, particularly examining the Cabbage head borer (Hellulaundalis F.) and tobacco caterpillar (SpodopteraLitura F). These investigations shed light on the vulnerabilities of cauliflower crops, which suffer significant losses ranging from 52% to 100% due to insect attacks, according to Anuradha (1997). Talekar (1992) estimates the global annual expenditure on managing these pests to be a staggering one billion US dollars. Notably, the tobacco caterpillar, Spodopteralitura F., emerges as the primary culprit, inflicting direct yield reductions and quality deterioration. Its voracious larvae engage in communal feeding, resulting in a characteristic 'mesh' pattern on leaves before transitioning to solitary, nocturnal habits, culminating in widespread defoliation. The indiscriminate use of pesticides has exacerbated the situation, endangering consumers and triggering pest resurgence, secondary outbreaks, and insecticide resistance. Integrated pest management (IPM) offers a sustainable solution, leveraging insecticides judiciously to suppress pest populations while preserving ecological equilibrium (Arora et. al 2014). Emphasis on biocontrol agents such as predators, parasites, and microbes underscores their specificity and efficacy in pest management, ensuring minimal collateral damage to beneficial organisms and the environment. The myriad biological effects of neem derivatives, ranging from antifeedant properties to disrupting metamorphosis, underscore their potential as eco-friendly alternatives (Gfeller et al., 2013). A current study in Bhadohi, Uttar Pradesh, delves into the toxic

impact of various neem formulations on different stages of Spodopteraliturafabricius, offering promising insights into eco-friendly IPM strategies tailored to safeguard cauliflower crops.

Materials and Methods

In the present chapter, details of material used and techniques employed for various investigations of the proposed plan of work have been dealt under the following appropriate heads.

Test Insect:

For the present investigation, Spodopteralitura F. was taken as a test insect. This pest is of polyphagous nature and has got a place of an economic importance and damages various commercial cultivations throughout the country.

Collection of Test Insect:

The eggs and larvae of Spodopteralitura were collected from Cauliflower fields in and around Nathaipur village near K.N. Government P.G. College, Bhadohi, and brought to the laboratory.

Mass Culture of test insect in laboratory:

The small larvae naturally feeding on the cauliflower leaves brought from the field were shifted to small plastic bags for rearing and they were finally shifted in test tubes covered with cotton plugs, to avoid their escaping. The neonate larvae were finally transferred to glass jars, containing fresh tender cauliflower leaves. The mouth of the jar was covered with a piece of plastic sheet having many small holes for proper aeration. The larvae were shifted on the tender leaves the following day and the plastic cover of the jar was replaced by a piece of muslin cloth and fresh leaves were supplied as required. They were shifted in glass jars measuring 15 cm. in diameter and 20 cm. in height having moist sterilized soil in the bottom of glass jars for pupation. The soil was replaced daily in the jar and excreta was cleaned with the help of a soft brush. Glass jars were also covered with black cloth held in place by an elastic band. The larvae fed successfully and the fresh leaves were supplemented as and when felt necessary. After completing their development, the larvae entered the soil for pupation. Such jars were kept undisturbed for 3-4 days for their pupation. The soil, from these jars, was sieved to obtain the earthen cocoons containing pupae, were finally shifted to the emergence chamber, containing moist soil. After a few days, the adults started emerging out. Males and females were identified as per the criteria laid down by Ridgeway (1912). In the male thorax, 3 wood brown stripes, one along the mid dorsal line and one on either side originating from near the base of each forewing and going backwards. Similar stripes were also present along the posterior margins of the wings and when wings were folded, they formed a wood brown stripes along the mid dorsal line. In females, these areas were not colored differently from the general brownish drab color of the body. These stripes were divided into narrow streaks by brownish drab scales. Males were buff but females were smoky gray in color ventrally.

Rearing of the test insect for observing toxic effects of Biopesticides:

For further studies, males and females were sorted out of known age from mass culture. They were kept in a 1:1 ratio for mating and oviposition in jars of the size (15 cm x 20 cm). The plastic strips measuring 2 cm width and 10 cm length were hung in these jars and tops of the jars were covered with cloth. Next day, the eggs were collected from these plastic strips with the help of No. 4 camel hair brush. These eggs were again fixed on the paper with the help of diluted gum and after drying, they were shifted to the same small plastic bags. Similar process was followed for rearing further generations as was followed for mass culture. When larvae hatched in the second generation in plastic bags, they were immediately shifted to fresh glass tubes containing fresh tender leaves and covered with cotton plugs. These 3 days old larvae were shifted to each homeopathic vial before introduction of treated leaves. These larvae were kept without food for a few hours.

Precautions in Rearing Larvae :

As the larvae get infections of nuclear polyhydrosis virus, great care was taken in rearing them. To avoid the trouble, strict sanitation and sterilization was maintained of laboratory equipment at 150°C for 4 hours. Plastic bags were treated with 0.05% sodium hypochloride for five and ten minutes, respectively, to avoid the infections of nuclear polyhedrosis virus. Other precautions like excess moisture were avoided. Excess moisture caused maximum mortality of larvae.

Biopesticides used:

Following biopesticides were used in the present investigations:

1. Bioneem
2. Nimbicidine
3. Econeem
4. Neemarin
5. Neemazal

Preparation Of BiopesticideFormulations :

Preparations of stock solution: For preparing solutions of insecticides, commercial grades were obtained and the desired concentrations of biopesticides were prepared by following formula:

Amount of insecticide =(Concentration desired × Amount desired) ÷(% a.i.(active ingredient) present the

available insecticide)

Amount of insecticide

=(Concentration desired × Amount desired)

÷(% a.i.(active ingredient) present the available insecticide)

Note: Neem formulations were considered as 100% Neem oil.

Experimental Findings

In this chapter, the findings of the experiments have been presented and described. The different aspects which have been studied are mortality effect in 3 day old larvae, when fed the treated larvae after treatment by neem formulations, variations in the life cycle under the influence of neem formulations and behavioral aspects.

EFFECT OF NEEM FORMULATIONS ON THE MORTALITY S. litura LARVAE

The present investigation was undertaken mainly to find out the effect of different neem formulations in their different doses to ascertain their best concentration for S. litura 24, 48, 72, 120, 144 and 168 hrs after the treatments. The S. litura larvae were fed treated leaves on the very first day. Five neem formulations i.e. Bioneem, Nimbicidine, Econeem, Neemarin and Neemazal, were tested on S. litura larvae. Percent concentrations used were 0.5%, 1% and 1.5% each of Bioneem, Nimbicidine, Econeem, Neemarin and Neemazal. This experiment was conducted during 2022 - 2023 in the laboratory of the Department of Zoology, K.N. Government P.G. College, Bhadohi. The results, thus, drawn have been highlighted under the following appropriate heads:

AFTER 24 HOURS

EFFECT OF NEEM FORMULATION:

The data pertaining to mortality percentage of S. litura larvae are documented in table-1. The effect of neem formulation reflected the mortality of S. litura larvae after 24 hours. In Bioneem, Nimbicidine, Econeem, and Neemarin, the mortality effect was not significant. However, Neemazal showed a rather higher percentage of mortality over the rest of the neem formulations.

The data were analyzed for individual exposure periods on larval mortality. Since, this was a simple experiment (CRD factorial) having five neem formulations in their three concentrations, hence the results have been presented as per the objectives and the result of analysis of variance has been presented in appendix with a reference here.

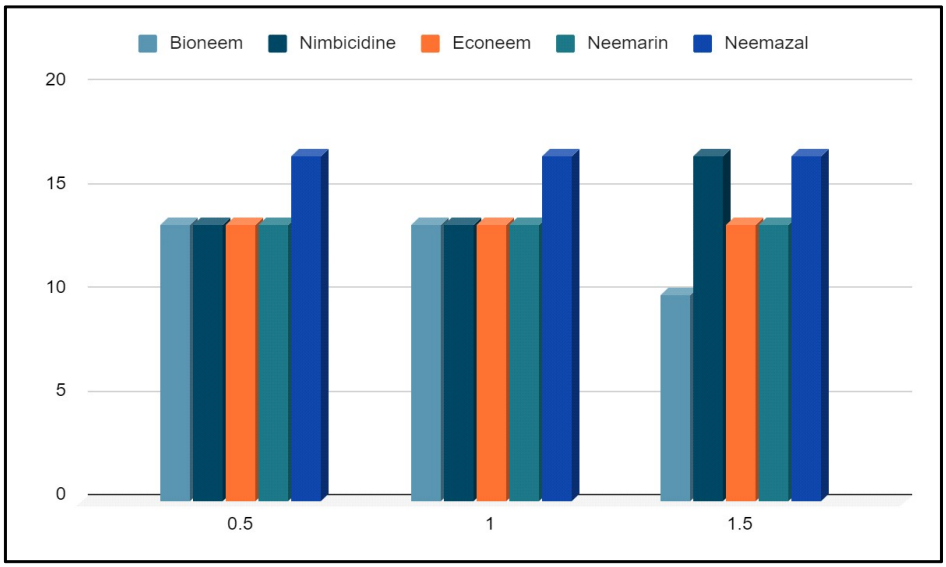
Table-1: Effect of Neem formulations at different concentrations on percentage mortality of three day old larvae of S. litura after 24 hours of treatment at different concentrations during larval period

Neem formulation	Concentrations			Mean
	0.5	1.0	1.5	
Bioneem	13.33 (21.15)	13.33 (21.15)	10.00 (18.44)	12.22 (20.24)
Nimbicidine	13.33 (21.15)	13.33 (21.15)	16.67 (23.85)	14.44 (22.03)
Econeem	13.33 (21.15)	13.33 (21.15)	13.33 (21.15)	13.33 (21.15)
Neemarin	13.33 (21.15)	13.33 (21.15)	13.33 (21.15)	13.33 (21.15)
Neemazal	16.67 (23.85)	16.67 (23.85)	16.67 (23.85)	16.67 (23.85)

Control Mean, 0.00 (0.00) Treatment Mean, 14.00 (21.69)

	SE (d)	CD
Formulation	2.07	N.S.
Concentration	1.60	N.S.
Interaction	3.58	N.S.
Cont. v/s treat	2.61	5.33

* Figures in parentheses are angular transformed values.



The data given in Table 1 shows the following result statistically:

* Effect of Neem Formulation:

The data pertaining to mortality percentage of larvae after 24 hours have been depicted in Table 1. Effect of neem formulation reflects the percent larvae mortality, obtained in Nimbicidine, Econeem, Neemarin and Bioneem did not differ significantly among themselves and from control, but Neemazal shows significantly higher mortality over the rest neom formulations and control.

* Effect of Concentration:

The different concentration of the neem formulations did not show variation in the mortality percentage of larvae after 24 hours of treatments.

* Effect of Interaction:

Interaction effects were non-significant but among all concentrations Neemazal showed higher mortality of larvae. The bioneem in different concentrations showed lowest mortality after 24 hours of treatment.

* Control v/s Treatment:

It is evident from the result of Table-1 that the control did not show any mortality of S. litura after 24 hours of treatment.

* AFTER 48 HOURS

* Effect of Neem Formulations:

The data pertaining to mortality percentage of larvae after 48 hours have been documented in Table-2. Effects of neem formulations reflect the mortality percentage of S. litura larvae significantly. Neemarin showed mortality percentage being (83.32%) over the other neem formulations after 48 hours of treatment. Bioneem showed 16.67 per cent mortality.

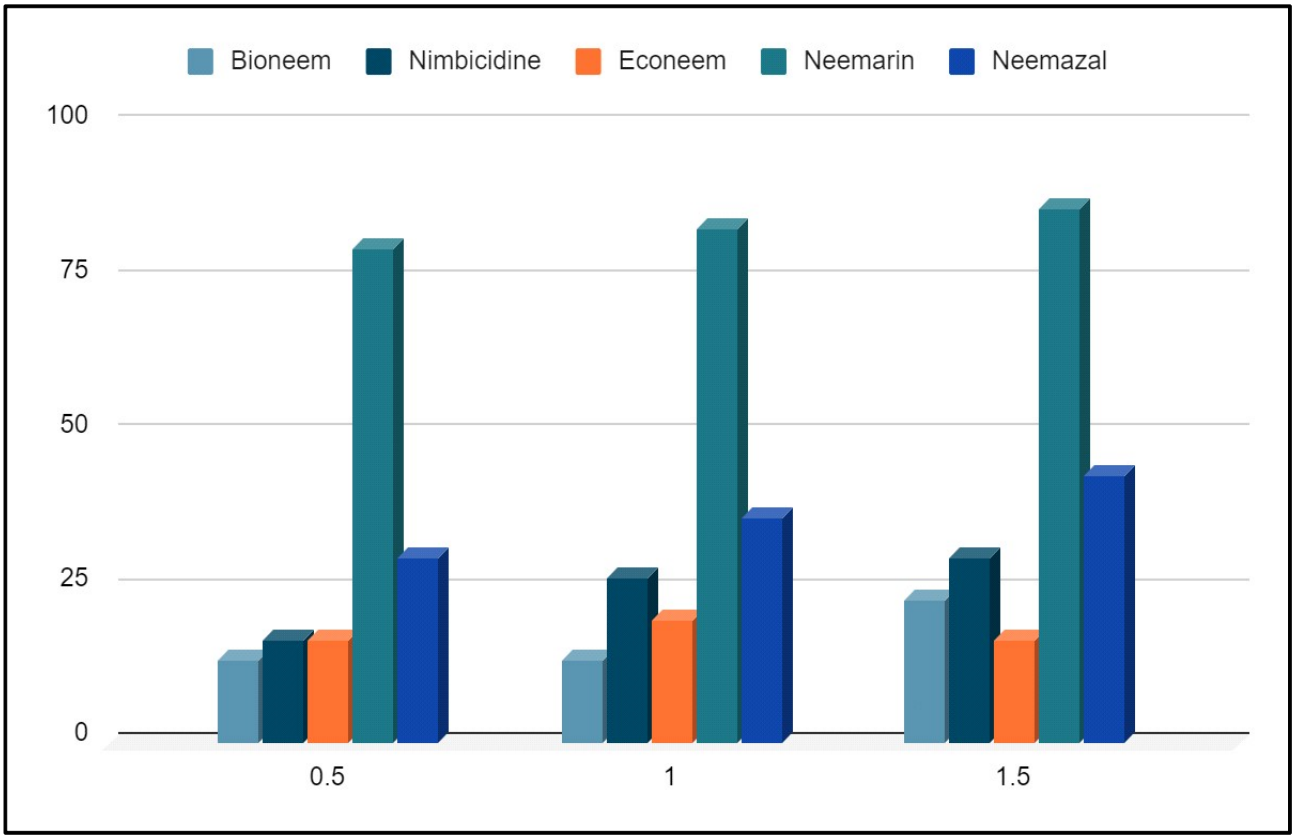
Table-2: Effect of Neem formulations on the mortality of two day old S. litura larvae.

Neem formulation	Concentrations			Mean
	0.5	1.0	1.5	
Bioneem	13.33 (21.15)	13.33 (21.15)	23.33 (28.15)	16.67 (23.85)
Nimbicidine	16.67 (23.85)	26.67 (30.99)	30.00 (33.00)	24.44 (29.28)
Econeem	16.67 (23.85)	20.00 (26.07)	16.67 (23.85)	17.78 (24.39)
Neemarin	80.00 (63.95)	83.33 (66.15)	86.67 (68.85)	83.32 (66.321)
Neemazal	30.00 (33.21)	36.67 (37.22)	43.33 (41.15)	36.67 (37.20)
Mean	31.33 (33.20)	36.00 (36.32)	36.67 (39.13)	35.78 (36.22)

Control Mean, 0.00 (0.00) Treatment Mean, 35.70 (36.22)

	SE (d)	CD (P = 0.05)
Formulation	2.22	4.53
Concentration	1.72	3.51
Interaction	3.85	N.S.
Cont. v/s treat	2.81	5.73

* Figures in parentheses are angular transformed values.



* Effect of Concentrations:

The higher concentration of the different neem formulations also reflected significantly the mortality percentage of S. litura larvae after 48 hours of observation. The higher concentration (1.5%) recorded higher mortality accordingly. Interestingly, Neemarin rendered more than 80% mortality at all the three concentrations. None of the larvae died in control at 48 hr. after their release as apparent from Table 2.

* Interaction Effect:

In different concentration neem formulations, Neemazal (1.5%) showed higher mortality percentage compared to other neem formulations after 48 hours.

* Control v/s Treatment:

There is no trace of mortality of S. litura larvae in control (Table 2).

* AFTER 72 HOURS:

* Effect of Formulations:

The data pertaining to mortality percentage of larvae after 72 hours have been portrayed in Table-3. Neemarin manifested a significantly higher percentage of larval mortality after 72 hours. Nimbicidine resulted in the lowest percentage of larval mortality followed by Neemazal (50.00%).

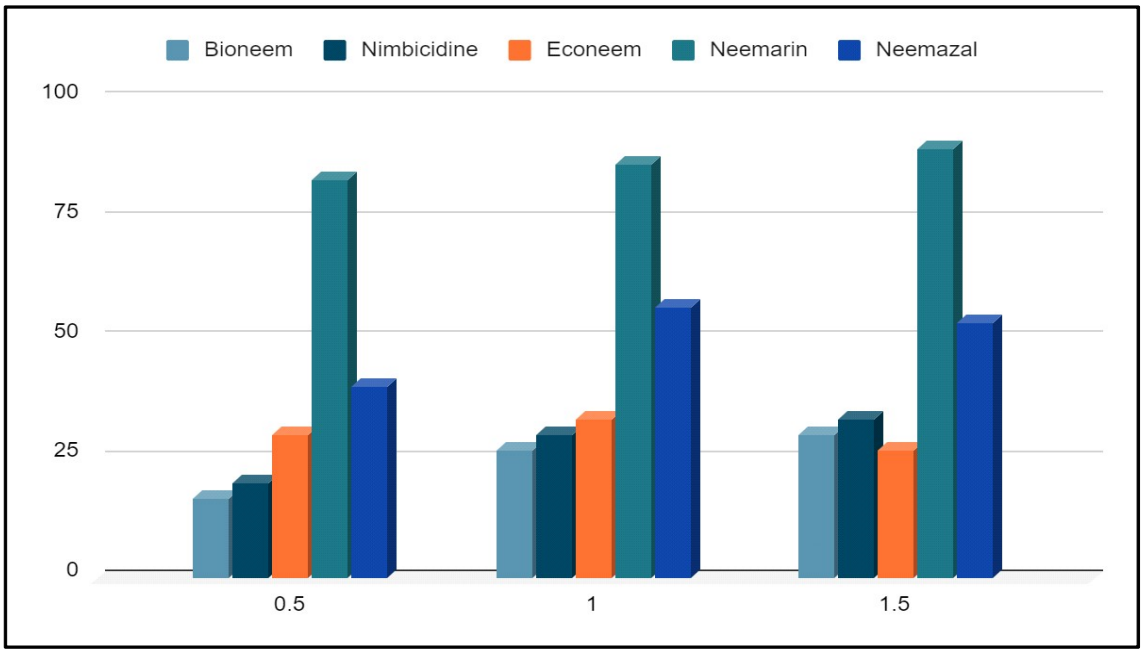
Table-3: Effect of Neem formulations on the mortality of three day old S. litura larvae.

Neem formulation	Concentrations			Mean
	0.5	1.0	1.5	
Bioneem	16.67 (23.85)*	26.67 (28.90)	30.00 (33.21)	24.44 (27.26)
Nimbicidine	20.00 (20.27)	30.00 (30.90)	33.33 (35.22)	27.78 (28.80)
Econeem	30.00 (33.21)	23.33 (28.29)	26.67 (30.29)	26.67 (29.83)
Neemarin	83.33 (66.15)	86.67 (68.85)	90.00 (71.56)	86.67 (68.85)
Neemazal	40.00 (39.23)	56.67 (48.85)	53.33 (46.92)	50.00 (45.00)
Mean	38.00 (35.24)	44.67 (41.16)	46.67 (43.44)	41.11 (39.95)

Control Mean, 0.00 (0.00) Treatment Mean, 35.70 (36.22)

	SE (d)	CD (P = 0.05)
Formulation	2.66	5.42
Concentration	2.06	4.20
Interaction	4.61	N.S.
Cont. v/s treat	3.37	6.86

* Figures in parentheses are angular transformed values



* Effect of Concentration:

Out of three concentrations, the higher concentration (1.5%) gave significantly higher mortality percentage followed by the remaining two lower doses.

* Effect of Interaction:

After 72 hours, significantly the interaction effect was observed in S. litura larvae mortality in different concentrations of neem formulations. Neemarin at 1.5 per cent concentration gave a higher percentage of mortality after 72 hours of treatment..

* Control v/s Treatment:

While accounting the control, the mortality of S. litura larvae was found nil after 72 hours of treatment.

* AFTER 120 HOURS:

* Effect of Formulation:

In different concentrations of neem formulations, a significant mortality percentage of S. litura larvae was observed after 120 hours. Neemarin has remarkably and consistently responded with the highest percentage of larval mortality after 120 hours of treatment. The Nimbicidine and Bioneem were at par in mortality percentage after 120 hours of treatment.

* Effect of Concentration:

In different concentrations of Neemarin, 1.5% concentration showed higher percentage of mortality is S. litura larvae over the rest to doses i.c. 1.0 and 0.5 per cent concentration after 120 hours of treatment.

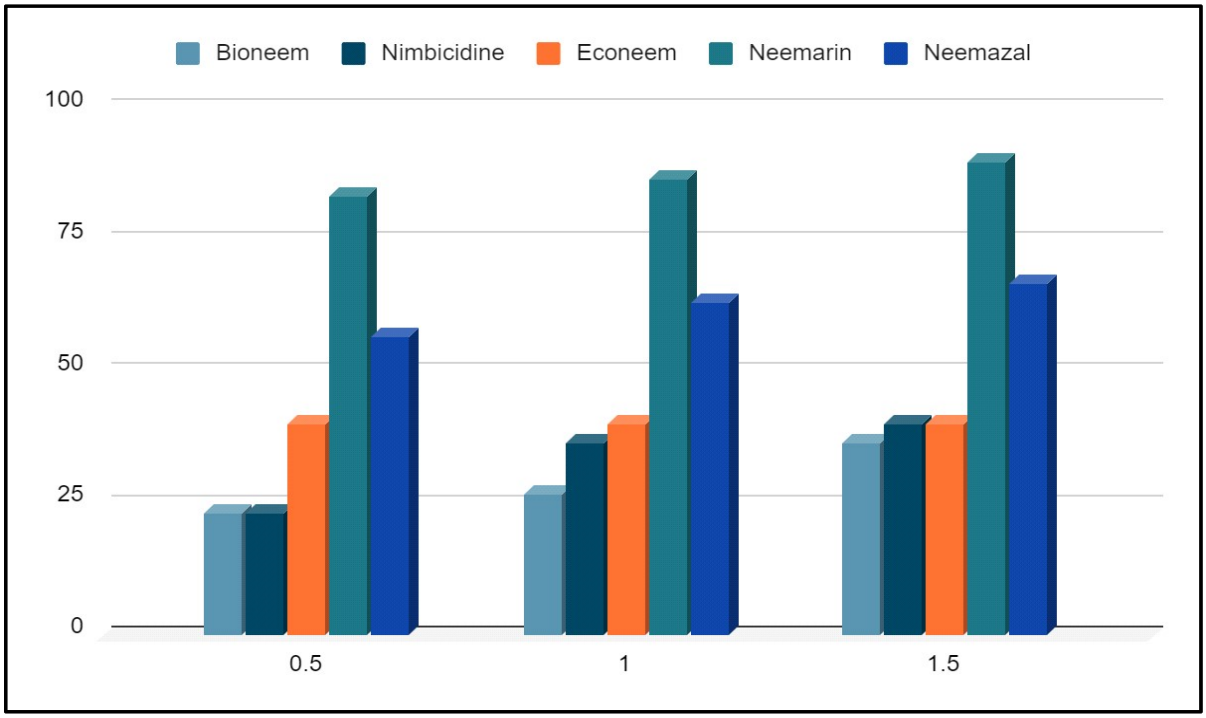
Table-4: Effect of Neem formulations on the mortality of five day old S. litura larvae.

Neem formulation	Concentrations			Mean
	0.5	1.0	1.5	
Bioneem	23.33 (28.89)*	26.67 (30.99)	36.67 (37.22)	28.89 (32.17)
Nimbicidine	23.33 (28.78)	36.67 (37.14)	40.00 (39.15)	33.33 (35.62)
Econeem	40.00 (39.15)	40.00 (38.85)	40.00 (38.85)	40.00 (38.85)
Neemarin	83.33 (66.15)	86.67 (68.85)	90.00 (71.56)	86.67 (68.85)
Neemazal	56.67 (48.85)	63.33 (52.78)	66.67 (54.78)	62.22 (52.14)
Mean	45.33 (42.24)	50.67 (45.72)	54.67 (48.31)	50.22 (45.52)

Control Mean, 0.00 (0.00) Treatment Mean, 43.11 (39.95)

	SE (d)	CD (P = 0.05)
Formulation	2.81	5.73
Concentration	2.18	4.44
Interaction	4.87	N.S.
Cont. v/s treat	3.56	7.24

* Figures in parentheses are angular transformed values.



* Effect of Interaction:

There was no significant difference in mortality percentage of S. litura. Neemarin 1.5 per cent gave the highest larvae percentage mortality after 120 hours of treatment.

* Control v/s Treatment:

The results in Table-4 clearly reveal that the untreated larvae of S. litura did not exhibit any mortality after 120 hours of treatment.

* AFTER 144 HOURS:

* Effect of Formulations:

It is evident from the results elicited in the Table-5 that the concentrations of Neemarin increased the larvae mortality of S. litura significantly (86.67%) after 144 hours of treatment over Neemazal (73.33%), Econeem (50.00%), Bioneem (40.00%) and Nimbicidine (36.67%), respectively. The Nimbicidine concentrations showed the lowest percentage of mortality of S. litura larvae after 144 hours of treatment.

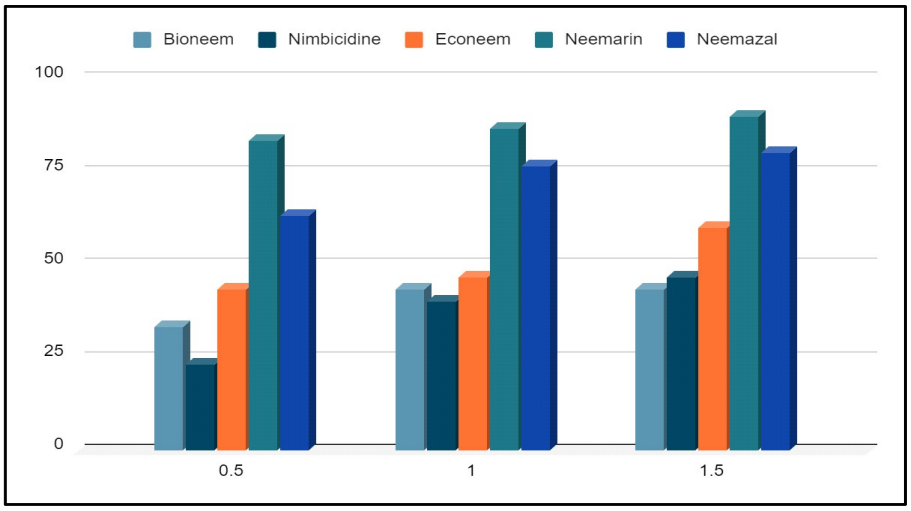
* Effect of Concentration:

The results showed the significant trend of the larval mortality with the increase in concentrations. The higher concentration (1.5%) significantly increased the mortality percentage of larvae after 144 hours of treatment.

Table-5: Effect of Neem formulations on the mortality of six day old S. litura larvae.

Neem formulation	Concentrations			Mean
	0.5	1.0	1.5	
Bioneem	33.33 (34.22)	43.33 (41.07)	43.33 (41.15)	40.00 (38.82)
Nimbicidine	23.33 (29.26)	40.00 (39.15)	46.67 (43.08)	36.67 (37.16)
Econeem	43.33 (41.16)	46.67 (43.08)	60.00 (51.15)	50.00 (45.13)
Neemarin	83.33 (66.15)	86.67 (68.85)	90.00 (71.56)	86.67 (68.85)
Neemazal	63.33 (52.78)	76.67 (61.22)	80.00 (63.44)	73.33 (59.15)
Mean	49.33 (44.71)	58.67 (50.67)	64.00 (54.07)	57.33 (49.82)

Control Mean, 0.00 (0.00) Treatment Mean, 57.33 (49.82)



* Interaction Effect:

There were significant differences among different combinations of concentration. The higher concentration of Neemarin increased the mortality percentage of larvae over other combinations after 144 hours of treatments.

* Control v/s Treatment:

No mortality was observed in control. It showed that all the neem based formulations are highly effective over control after 144 hours of treatment.

* AFTER 168 HOURS:

*Effect of Formulations:

It is obvious from Table 6 that Neemarin formulation increased the mortality percentage of larvae of S. litura significantly over the other neem formulations after 168 hrs of treatment. The Nimbicidine behaved significantly lowest mortality of larvae.

* Effect of Concentration:

The results in Table-6 clearly indicated that the higher concentration (1.5%) significantly increased the mortality percentage of S. litura larvae after 168 hours of treatment.

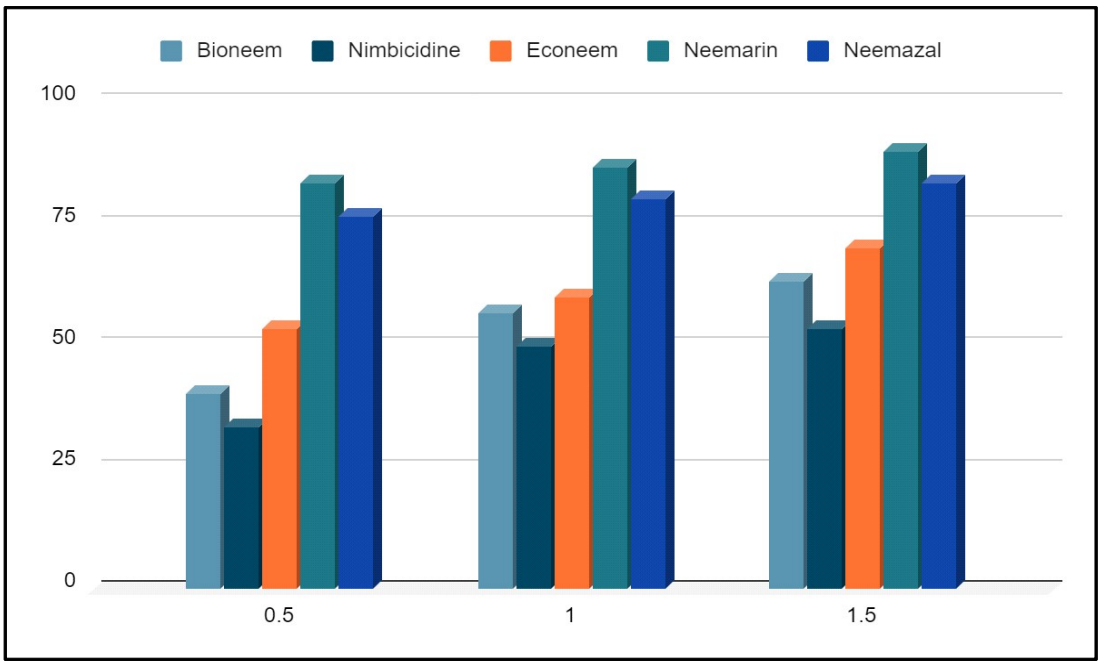
Table-6: Effect of Neem formulations on the mortality of seven days old S. litura larvae

Neem formulation	Concentrations			Mean
	0.5	1.0	1.5	
Bioneem	40.00 (38.85)*	56.67 (48.85)	63.33 (52.78)	53.33 (46.82)
Nimbicidine	33.33 (34.92)	50.00 (45.00)	53.33 (46.92)	45.56 (42.28)
Econeem	53.33 (47.30)	60.00 (51.15)	70.00 (57.00)	61.56 (51.82)
Neemarin	83.33 (66.15)	86.67 (68.85)	90.00 (71.56)	86.67 (68.85)
Neemazal	76.67 (61.22)	80.00 (63.44)	83.33 (66.15)	80.00 (54.67)
Mean	57.33 (49.69)	66.67 (55.46)	72.00 (58.88)	65.33 (54.67)

Control Mean, 0.00 (0.00) Treatment Mean, 57.33 (49.82)

	SE (d)	CD (P = 0.05)
Formulation	3.11	6.34
Concentration	2.41	4.91
Interaction	5.39	N.S.
Cont. v/s treat	3.94	8.02

* Figures in parentheses are angular transformed values.



* Interaction Effect:

There were no significant differences observed in the mortality percentage of larvae. Different concentrations of Neemarin rendered non- significant difference in the mortality of larvae after 168 hours of treatment. There was no mortality in control of S. litura larvae after 168 hours of treatment. The treated larvae manifested the higher mortality over the population of control.

Discussion

In the present comprehensive investigation, an array of neem formulations, namely Bioneem, Neemarin, Nimbicidine, Neemazal, and Econeem, were subjected to rigorous scrutiny concerning their bioefficacy against the larvae of Spodopteralitura (F). This endeavor involved meticulous monitoring of larval mortality at regular intervals spanning 24, 48, 72, 120, 144, and 168 hours post-treatment.

Upon the initial 24-hour assessment, Neemazal emerged as the frontrunner, exhibiting the most pronounced mortality percentage. Noteworthy observations included the expulsion of a distinctive greenish fluid by Neemazal-treated larvae, alongside noticeable retardation in larval growth, particularly evident at concentrations of 1.0 and 1.5 percent. It's worth highlighting the gradual but steady mortality across all concentration levels (0.5%, 1.0%, and 1.5%) within the initial 24-hour timeframe.

Subsequent scrutiny at the 48-hour mark unveiled compelling findings, with Neemarin showcasing a remarkable mortality rate of 83.3%, outperforming all other neem formulations. Conversely, Bioneem displayed the lowest larval mortality at a modest 16.67%. These outcomes resonated with the findings of esteemed researchers such as Sintim et al. (2009) and Mukherjee (2003), reinforcing the influential role of Neemarin, particularly attributable to its Sesame extract content.

Moving forward to the 72-hour milestone, Neemarin continued its dominance, registering a further surge in mortality, soaring to an impressive 86.67%. Concurrently, Nimbicidine demonstrated mortality rates akin to Econeem. The significance of these findings was accentuated by the work of Sharma et al. (2008) and Jeyasankar et al. (2013), who emphasized the oviposition deterrent potential inherent in ethyl extracts.

The subsequent evaluation post-120 hours revealed a notable escalation in mortality against Neemazal, positioning it prominently among the formulations tested. Neemarin sustained its momentum, followed closely by Neemazal, Econeem, Nimbicidine, and Bioneem, in descending order of efficacy. Intriguingly, Neemarin exhibited a temporal halt in mortality progression after 72 hours, with a subsequent resurgence observed after 120 hours across all treatment groups.

The gradual mortality pattern observed in S. litura larvae underscored the nuanced impact of the various formulations, particularly attributed to their feeding restrictions. These findings echo the sentiments echoed by Patil et al. (2014), Santis et al. (2012), and Sabri (2017), shedding light on the efficacy of insecticides like chlorantraniliprole and Spinosad against S. litura larvae.

Given the relatively lower toxicity profile of neem formulations compared to conventional insecticides, the study extended its observations to discern any latent effects on treated larvae. Impressively, Neemarin exhibited unparalleled efficacy after 144 hours, underscoring its potency, with Neemazal, Econeem, Bioneem, and Nimbicidine following suit, albeit at varying degrees. These findings align harmoniously with the research endeavors of Saini et al. (2005), Gmail et al. (2011), and Dhawan et al. (2007), further corroborating the effectiveness of diverse insecticides against S. litura larvae.

Furthermore, visual inspections utilizing colored plates elucidated a stark depiction of retarded growth and larval shrinkage, particularly conspicuous in Neemarin-treated specimens. Pupation inhibition, attributed to a staggering 90% mortality after 168 hours of treatment, underscored the profound impact of Neemarin. Meanwhile, Neemazal emerged as the runner-up, with an impressive 80% mortality rate after 168 hours, whereas Nimbicidine displayed the lowest mortality percentage at 45.56%.

In essence, this comprehensive study offers valuable insights into the varying efficacy of neem formulations against S. litura larvae, with Neemarin emerging as the undisputed leader. These findings not only enrich our understanding of botanical insecticides but also underscore their potential in the broader context of integrated pest management strategies.

Our study aligns with the agronomic trial conducted by Sapkota et al. (2023), highlighting the strong effectiveness of neurotoxic agents. Just as Neemarin showed high larval mortality against Spodopteralitura, Spinosad and Emamectin benzoate effectively reduced pest numbers and increased cauliflower yield, supporting their role in integrated pest management.The studies conducted by Kanna et al. (2023) and Li Y et al. (2022) align with our original research by utilizing advanced deep learning techniques to enhance agricultural productivity-one focusing on early disease detection in crops and the other on surface defect recognition in fresh-cut cauliflower-thus supporting effective plant health and quality management, similar to our work on biopesticides against Spodopteralitura.

References

1. Bhakta R, Cupta D. Insect and mite pest status of subtropical horticultural crops in Himachal pradesh. Journal of Insect Science 2003; 16:1-8
2. Meghana C, Jayappa J, Reddy N.A, V. Sridhar Jyathi. Assessing susceptibility of diamondback moth Plutellaxylostella (Lepidoptera plutellidae) Population of different geographic regions to selected newer Insecticides. Journal of Entomology and Zoology Studies 2015; 6: 16-19.
3. Talekar N.S. (1992). Diamondback moth and other crucifer pests. Proceedings of the second International Workshop AVRDC, Taiwan: pp.10-14.
4. Duraimurugan, P. and Srinivas P.S. 2017 Evaluation of poison baits against tobacco caterpillar Spodopteralitura in castor. J. Exp. Zool. India 20; 745-749.
5. Arora, S., Mukherji, I., Kumar, A., and Tanwar, R., Pesticides residue analysis of soil, water and grain of IPM basmati Rice, Environ Monit. Assess. (2014) 186, 8765-8772- doi: 10.1007/s10661-014-4042-9)
6. Gfeller, A., Laloux, M.,;Barsic, F.,, Kati, D.E., Haubruge, E., Du Jardin, P., Characterization of volatile organic Compounds emitted by Barley Roots and their alternatives to wireworm, J. Chem. Ecol. 2013, 39: 1129-1139
7. Sintim, H., Tashiro, T., and Motoyama, N (2009) Response of the cutworm spodopteralitura to sesame leaves or crude extract in diet. Journal of Insect science 9; 1-13.
8. Mukherjee; S (2003) Influence of plant allelochemicals on growth rate, Nutrition Physiology and midgut esterase activity in fifth instar larvae of spodopteralitura, production and development. Indian journal of plant protection 41, 125-132.
9 Jeyasankar A, Elumali, K, Raja N and Ignacimuthu, S. (2013). Effect of plant chemicals on oviposition deterrent and ovicidal activities against female moth. S. litura Int. J. Agric. Sci and Research 2(6), 206-213
10. Sharma A, Gupta R and Kanwar R. (2008) effect of plant extract on fecundity of Spodopteralitura. Indian J. Plant protection 36(1), 139-141,
11. Sabri, M.A., Islam, M.S.; Hussain, D. and Saleem M. (2017) Evaluation of lethal response of biorational insecticides against spodopteralitura. J. Entemol Zoo Study 4(4): 270-274.
12. Ahmad, M. and Gull S. (2017) Susceptibility of armyworm spodopteralitura to Novel insecticides in Pakistan. Canadian Entomol 149(5) 649-661
13. Dhokal, R., Ghimire, R., Sapkota, M., Bhatta, A.K., Thapa. S, and Regmi, R. (2019). Bioefficacy of different insecticides on cowpea aphid Int. Entomol. Res 7, 1-7.

13 Laxman, G., Sharma R, and Sinha, S. (2019) Field efficacy of biopesticides against diamondback moths and aphids on cabbage. Pestic Res J. 31, 54-59

14. Nayak, S.C. (2013) Efficacy of some Biopesticides against the pest of cabbage at Bhubaneswar University of Agriculture, Bhubaneswar, Orissa.

15. Panta, C., Regmi, R, Bhusal, S., Yadav, S. Tiwari, S., Wagle, P., and Bhandari, M., (2021) efficacy of commercial insecticides for the management of cowpea borer on cowpea under field condition in Chitwan, Nepal. Food AgribusManag., 2, 92-95

16. Saini, R.K., Kumar, S., Sharma, S.S. (2005) Evaluation of Insecticides against Spodopteralitura (Fab). attacking cotton. J. Cotton Res. Dev. 2005, 19(2): 273-276

17. Gmail, W.E., Mariy, F.M., Youssef, L. A., Halim, S. M. A., (2011) Effect of Indoxacarb on some biological and biochemical aspects of spodopteraLittoralis (Boisd) larvae. Annal of Agri. Sci. 56(2):121-126

18. Dhawan, A.K., Kour, Ashwinder and Kumar Ravinder (2007). Relative toxicity of New insecticides against SpodopteraLitura (Fab). Ann. plant. Protec. Sci. 15:238-239.

19. Sapkota, Dikshya&Adhikari, Gaurav &Regmi, Rajendra&Bista, Dabit. (2021). Ecofriendly Management of Insect Pests of Cauliflower, Brassica oleracea var. botrytis in Kapurkot, Salyan, Nepal. Biopesticides International. 17. 59-68.

20 Kanna, G.P., Kumar, S.J., Kumar, Y. et al. Advanced deep learning techniques for early disease prediction in cauliflower plants. Sci Rep 13, 18475 (2023). https://doi.org/10.1038/s41598-023-45403-w

21. Li Y, Xue J, Wang K, Zhang M, Li Z. Surface Defect Detection of Fresh-Cut Cauliflowers Based on Convolutional Neural Network with Transfer Learning. Foods. 2022; 11(18):2915. https://doi.org/10.3390/foods11182915

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Traditional Hair Care Practices and Medicinal Plant-Based Treatments for Alopecia in Chhattisgarh: A Comprehensive Review

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ABSTRACT

Thisreview article presents a broad idea of dominantunexploited medicinal plants of Chhattisgarh region, which are used as aremedy for most of the hair related difficulties. It also highlights and reviews the potential of herbs and botanicals in hair care and rejuvenation. Also, present evidences about different herbs and botanicals with a brief description of the plant parts and their active compounds that are supposed to be able to diminish the frequencyof hair loss (Alopecia) and at the same time stimulate new hair follicles growth. Since the early pre-historic era, the herbal industry has developed quickly. In this piece of work,numerous herbal formulations are also mentioned which are very effective and hence, goal of current manuscript is to gather and disseminate information on the local flora that are used in hair management. Researchers that intend to investigate medicinal plants for prospective ingredients in hair care formulations might use this review as a wealth of information.

Keywords- Alopecia, Chhattisgarh, haircare, medicinal plants.

INTRODUCTION:

Hair is the God's most gracious present given to humans, which not only serves as a protective appendage for their head but also provides their physical appearance looks more appealing. Since the dawn of humankind, both sexes and people of all races have experienced varying degree of hair loss at any point of time in their lives (Roy et al., 2007).Hair loss, termed alopecia is a familiar dermatological disorder and an ever-increasing problem. As compared to chemical products, herbal ingredients are more preferred because of their easy availability at affordable prices,and fewer side effects. The upsurge for discovering natural products with hair-growth promoting potential is continuous(Jain et al.,2016).

The potential of medicinal herbs for controlling hair health has long been acknowledged by traditional healers. Chhattisgarh being one of the richest floristic regions of India and is well known for its rich and ancient inheritanceconcerning medicinal plants, herbs, and botanicals.The fact that all the ingredients in herbal hair care formulations are natural and authentic is one of the most crucial and significant aspects of their worldwide popularity, also. Thephytochemicals and secondary metabolites present in these medicinal plants or herbs do not cause any negative reaction to our hair or body. Instead, coupled with the topical application and ingestion of oral supplements, they aid in improving hair luster, shine, volume , thinning and follicles regeneration too. Examples of medicinal plants includes Lawsonia inermis L., (Henna), Hibiscus rosa-sinesis L., (Java), Phyllanthus emblica Linn., (Amla) and many more (Kaur et al., 2020).

MATERIALS AND METHODS:

This review project was carried out in 2022 utilizing the primary database from the ethnobotanical field and examined scientific works, published in books and journals in several electronic databases (including ScienceDirect, ResearchGate, Medline, PubMed, and Google Scholar) during the years 2002 to 2021. Only papers written in English are gathered, examined, and reviewed from international and national organizations. The information in all these publications is about the plants that are used in hair care.The included articles were searched using keywords 'Alopecia', 'Chhattisgarh', 'Hair', 'Medicinal plants'. From numerous research papers relating to the ethno-botanical studies that were carried out in the Chhattisgarh state, pertinent information was acquired concerning hair loss and herbal hair care treatments using floristic studies (Dewangan et al., 2011, Macdonald et al., 2015).

RESULTS:

Table.1, List of Herbal drugs/Medicinal plants used by locals and tribals of Chhattisgarh for Hair-care

Local name	**Scientific name**	**Family**	**Parts used**	**Method**	**References**
Amla	Phyllanthus emblica L.	phyllanthaceae	Fruit	Paste	Singh et al., 2014
Gudhal	Hibiscus rosa-sinesis L.	Malvaceae	Flower, leaves	Paste	Agrawal et al., 2018
Neebu	Citrus limon (L.) Osbeck	Rutaceae	Fruit	Juice	Kumar et al., 2016
Badam	Prunus dulcis Mill.	Rosaceae	Seed	Oil	Singh et al., 2015
Henna	Lawsonia inermis L.	Lytheraceae	Leaf	Leaf powder	Singh et al., 2015
Shikakai	Acacia concinna DC.	Fabaceae	Fruit	Cleanser	Gupta et al., 2010
Ritha	SapindusmukorossiGaertn.	Sapindaceae	Fruit	Cleanser	Goyal et al., 2014
Bhringraj	Eclipta prostrate (L.) L.	Asteraceae	Whole Plant	Paste	Herman et al., 2017
Gondli/Pyaj	Allium cepa L.	Amaryllidaceae	Bulb	Paste, oil	Upadhyay et al., 2016
Gunja	Abrus precatorius L.	Leguminosae	Seed	Paste, oil	Patel et al., 2015
Nirgundi	Vitex negunda L.	Verbenaceae	Leaf, root	Oil	Kumar et al., 2020
Bahera	Terminalia bellerica (Gaertn.)	Combretaceae	Fruits	Powder, oil	Sharma et al., 2021
Haritaki	Terminalia chebula Retz.	Combretaceae	Fruits	Powder, oil	Cathelin et al., 2021
Manjistha	Rubia cardifolia L.	Rubiaceae	Leaves	Powder, Oil	Pal et al., 2019

Table 2. Phytoconstituents having hair growth activity

Constituent	Category	Biological source	References
Piperine	Alkaloid	*Piper nigrum* L.	Hirata et al., 2010
3,4-dihydroxy benzaldehyde	Terpenoids	*Polyporusumbellatus* (Pers.)	patel et al., 2015
Capsaicin	Alkaloid	*Capsicum annum* L.	Harada et al., 2007
Proanthocyanidins	Flavonoids	*Vitus vinifera* L. (Grape seed)	Patel et al., 2015
Epigallocathechin 3-gallate	Flavanoids	*Camellia sinesis* (L.) (Green tea)	Patel et al., 2015
Procyanidin B-3	Flavonoids	*Hordeum vulgare* L. (Barley)	Kamimura et al., 2002
Procyanidin B-2	Flavonoids	*Malus domestica* Borkh.(Apple)	Kamimura et al., 2002.
Ginsenoside R_o	Saponin	*Panax ginseng* L.	Murata et al., 2012
Hinokitiol	Alkaloid	*Chamaecyparis obtuse Thuja plicata* Don	Byeon et al., 2008
Isoflavone	Flavones	Various legume plant	Harada et al., 2007
Bisbenzyllisoquinoline	Alkaloid	*Stephania cepharantha* Hayata	Patel et al., 2015
Soyasaponin 1	Saponin	*Pueraria thomsonii (Benth.) Maesen*	Murata et al., 2012
Kaikasaponin 111	Saponin	*Pueraria thomsonii (Benth.)* Maesen	Murata et al., 2012
Norgalanthamine	Alkaloid	*Crinum asiaticum*Linn.	Kim et al., 2010
Senegose A, Senegin 11, Senegin 111, Senegasaponin b	Polysaccharide Saponin	*Polygara senega* Torr.	Patel et al., 2015
Nardin Jatamansic acid	Sesqueterpene Acid	*Nardostachysjatamansi* DC	Gottumukkala et al., 2011
6- Gingerol	Flavanoid	*Zingiber officinale*	Miao et al., 2013
Ginsenoside F2	Saponin	*Panax ginseng* L.	Shin et al., 2014
Acetosyringe and Polyporusterone A & B	Steroids	*Polyporusumbellatus* (Pers.)	Patel et al., 2015

Table 3. Herbal formulations.

Plants in Herbal Formulation	Formulation	References
CitruluslimonisOsbek, *Cuscutareflexa*Roxb., *Emblica officinalis* L., *Centella asiatica* (L.) Urban, *Allium cepa* L., *Lawsonia inermis* L., *Azadirachtha indica* (L) Adleb., *Eclipta alba* (L.) Hassak, *Ocimumsanctum* Linn., and *Eugenia caryophyllus* Thunb.	Herbal hair oil	Kumar et al., 2010
Hibiscus rosa-sinesis L., *Tridax procumbens* L.	Herbal hair oil	Hati et al., 2010
Eclipta alba (L.) Hassak, *Hibiscus rosa-sinesis* Linn, *Nardosstachysjatamansi* DC	Herbal hair oil	Thorat et al., 2009
Emblica officinalis, *Centella asiatica* (L.) Urban, *Aloe vera* (L.) Burm.f., *Ocimum sanctum* Linn., *Eclipta alba* (L.) Hassak	Polyherbal Ointment	Patel et al., 2015
Trigonella foenum-graceum Linn., *Semecarpus anacardium* L.F., *Trigonella corniculata* (L.)	Herbal gel	Semalty et al., 2010
Butea monosperma and *Trigonella foenum-graceum* Linn.	Herbal hair ointment	Gupta et al., 2013
*Arnica montana*L., *Aloe socotrina* Linn., *Emlica officinalis*Gaertn, *Terminalia chebula* Retz, *Nyctanthesarbortristis* L., *Pilocarpusjaborandi* Vahl	Herbal Cream	Yadav et al., 2014
Tridax procumbens Linn., *Hibiscus rosa sinesis*Linn., *Trigonellafoenumgreacum* Linn., *Emblica officinalis* Linn.	Herbal hair oil	Sabarwal et al., 2009
Embellica officinalis Linn, *Hibiscus rosa sinesis* Linn, *Bacopa monnieri* L., *Trigonella foenumgreacum* Linn	Herbal hair oil	Benerjee et al., 2009

CONCLUSION:

Plant selection in the study of natural products is a difficult process. Because Chhattisgarh has such a diverse range of plant species, the locals are well-versed in using plants as hair care products. Also, these people are very connected to mother nature. Some of the plants utilized in Chhattisgarh for hair health purposes are described in this paper. In this review, we summarized some of the herbs that are thought to slow hair loss while also promoting the growth of new hair. I also compiled the phytoconstituents having hair care activity. Finally, I want to draw attention to the fact, that only a few plant species have been mentioned and listed in this paper. In fact, the number of plant species is considerably greater and continues to grow. Therefore, I tried to gather these disparate facts into a single document for the upcoming scientific studies pertaining to ethnobotanical and herbal hair care interests.

Future perspective:

In future, delivery of herbal hair care active components requires a new study direction, since hair condition research become highly consequential and will achieve tremendous progress in this research area. The desire for an effective hair care formulation can be met by expanding the use of medicinal plants, if theyare properly scientifically validated.

REFERENCES:

1. Roy, R. K., Thakur, M., & Dixit, V. K. Development and evaluation of polyherbal formulation for hair growth-promoting activity. J. Cosmet.Dermatol. 2007 6(2), 108-112. https://doi.org/10.1111/j.1473-2165.2007.00305.x
2. Jain, P. K., Das, D., &Singhai, A. K. Alternative herbal drugs used for treating hair disease. Asian J Pharm Clin Res. 2016 9(1), 75-7.
3. Kaur, A., Singh, T. G., Dhiman, S., Arora, S., & Babbar, R. Novel herbs used in cosmetics for skin and hair care: A review. Plant Arch. 2020 20(1), 3784-3793.
4. Dewangan, K., Acharya, V., Naik, M. L., &Girolkar, A. K. Home medicines of Chhattisgarh. Indian J. Appl. Pure Biol.2011 6, 47-52.
5. Macdonald, H. M. Skillful revelation: Local healers, rationalists, and their 'trickery'in Chhattisgarh, Central India. Med. Anthropol. 2015 34(6), 485-500.
6. Singh, N., Pandey, M. K., Sharma, A., & Prakash, J. . Indian medicinal plants: For hair care and cosmetics. WorldJ.Pharm. Pharm. Sci. 2014 1552-1556.
7. Agrawal, S. S., Ahmad, M., & Mazhar, M. Therapeutic Potential of Some Medicinal Plants in Alopecia. Int. j. innov. Sci. technol. 2018 3(7) 290-296.
8. Kumar, D., Rajora, G., Parkash, O., Antil, M., & Kumar, V. Herbal cosmetics: An overview. Int. J.Adv. Sci. Res. 2016 1(4), 36-41.
9. Singh, D. K., Luqman, S., & Mathur, A. K. Lawsonia inermis L.-A commercially important primaeval dying and medicinal plant with diverse pharmacological activity: A review. Ind. Crops. Prod. 2015 65, 269-286.https://doi.org/10.1016/j.indcrop.2014.11.025
10. Gupta, A., Malviya, R., Singh, T. P., & Sharma, P. K. Indian medicinal plants used in hair care cosmetics: a short review. Pharmacogn. J. 2010 2(10), 361-364.
11. Goyal, S. Medicinal plants of the genus Sapindus (Sapindaceae)-A review of their botany, phytochemistry, biological activity and traditional uses. J. Drug.Deliv. Ther. 2014 4(5), 7-20.
12. Herman, A., & Herman, A. P. Topically used herbal products for the treatment of hair loss: preclinical and clinical studies. Arch. Dermatol. 2017 309, 595-610.
13. Upadhyay, R. K. Nutraceutical, pharmaceutical and therapeutic uses of Allium cepa: A review. Int. J. Green Pharm. 2016 10(1) 46-64
14. Patel, M. H., Doshi, K. A., & Winston, C. GUNJA (ABRUS PRECATORIOUS LINN.)-A NOXIOUS PLANT-A REVIEW. Pharm. Sci. Monit.2015 6(3), 41-55
15. Kumar, P., & Kumari, S. (2020). Pharmacological Properties OfNirgundi: A Review. Int. J. Ayurveda. Pharma. Res. 2020 8 68-73.
16. Sharma, P., Verma, K. K., Raj, H., & Thakur, N. A review on ethnobotany, phytochemistry and pharmacology on Terminalia belerica (Bibhitaki). J. Drug Deliv. Ther. 2021 11(1-s), 173-181.

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Drought Management in Tikamgarh District: Implementing Water "Harvesting as a Key Sustainable Solution for Long-term Water Security

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Abstract-

This study examines the critical problem of water scarcity in Tikamgarh district, a dry area prone to frequent droughts. The research investigates water harvesting as a viable, long-term approach to alleviate drought effects. The paper thoroughly examines several water harvesting methods, such as rooftop rainwater collection, check dams, contour trenching, percolation pits, and farm ponds. These techniques are assessed for their suitability to Tikamgarh specific geographic and climatic conditions. The study underscores the vital importance of water harvesting in enhancing water availability, maintaining agricultural activities, and strengthening community resilience. Through the presentation of case studies and successful implementations, the research offers practical knowledge to guide decision-makers, local officials, and communities in executing effective water harvesting initiatives. The outcomes of this investigation contribute to the larger conversation on sustainable water management and are relevant to regions worldwide facing similar water-related challenges.

Key Words- Drought, Water, Harvesting, Conservation.

Introduction-

Water, a limited and vital resource, requires sustainable management to tackle challenges arising from climate change, population increase, and growing agricultural and industrial demands. Water harvesting, an effective method involving rainwater collection and storage, plays a crucial role in ensuring water security. This study examines the importance of water harvesting, particularly in drought-prone areas, and its potential implementation in Tikamgarh district (Grewal et al. 1989) This sustainable, traditional practice captures and stores rainwater for various uses, including domestic, agricultural, and industrial purposes. By capturing rainfall and reducing runoff, water harvesting conserves water resources and alleviates drought effects. Its ability to improve water availability, especially in water-scarce regions, has garnered worldwide recognition(Domeneech & Sauri 2011).

Areas prone to drought, characterized by irregular and insufficient rainfall, experience severe water shortages that negatively impact agriculture, livelihoods, and ecosystems. Water harvesting offers a strategic solution in these regions by providing an alternative water source during dry periods. The collected rainwater serves as a valuable reserve for sustaining agricultural activities, supporting communities, and preserving local environments, thus reducing these areas' vulnerability to drought impacts (Dile et al. 2013). Tikamgarh district, situated in Madhya Pradesh, India, exemplifies the challenges faced by arid and semi-arid regions. With an agriculture-based economy heavily reliant on rainfall, Tikamgarh has long struggled with water scarcity, particularly during extended dry spells (Mustaq & Farjana 2015). The district's vulnerability to drought is intensified by factors such as climate variability, inadequate water infrastructure, and overreliance on traditional water sources (Singh & Kumar 2015). Tikamgarh district experiences frequent droughts that negatively affect crop yields, livestock, and the region's overall socio-economic structure. Insufficient and erratic rainfall, combined with unsustainable water management practices, worsens the severity of drought episodes. Consequently, there is an urgent need to investigate innovative and sustainable solutions to enhance water availability and resilience in Tikamgarh district (Pathare et al. 2021) The subsequent sections of this paper explore specific water harvesting techniques that show promise in mitigating drought impacts in Tikamgarh district, thereby contributing to the region's overall water security.

Location of the study area-

The Tikamgarh district is located between latitudes 24.26° to 25.40° north and longitudes 78.26° to 79.26° east. It has an average elevation of 349.170 meters. The Betwa River runs along the western and northern boundaries of the district, which lies within the Ganga drainage basin. The Dhasan River, a key river in the area and a right-bank tributary of the Betwa, forms the district's

eastern boundary. The flow of these rivers defines the district's hydrological framework. The Dhasan River is a crucial water source, supplying approximately 75% of the district's water needs through diversions into several smaller rivers. Tributaries of the Betwa River, including the Jamni, Bagri, and Barua, traverse the Tikamgarh region. The district covers a drainage area of approximately 5,048 square kilometers.

Methodology-

This research aims to conduct a thorough review of literature on water harvesting techniques, drought mitigation strategies, and relevant studies, specifically focusing on Tikamgarh district. The goal is to create a solid foundation for understanding theoretical concepts and identifying effective practices in water resource management within this area. The study's methodology involves conducting field surveys to gather primary data and interviewing various stakeholders, including local farmers, community leaders, water management officials, and other relevant parties. These efforts seek to understand the participants' viewpoints, experiences, and challenges related to water scarcity, as well as explore potential water harvesting solutions in the research area (Mustaq et al. 2016). The study will utilize Geographic Information System (GIS) mapping to analyse the spatial distribution of water resources, map land use patterns, and evaluate potential sites for implementing water harvesting techniques (Mustaq & Farjana 2015). GIS will play a crucial role in identifying suitable locations for various methods, considering factors such as terrain variations, soil types, and hydrological features, thus enabling a scientifically-based approach to sustainable water resource management. Quantitative methods will be employed to measure and quantify key parameters, including rainfall patterns, water table levels, and soil moisture content. These on-site measurements will be supplemented with meteorological data from relevant authorities, ensuring a comprehensive and rigorous approach to quantitative data collection.

Criteria for selecting Water Harvesting techniques.

The Tikamgarh district exhibits significant variability and a unique distribution in its rainfall patterns. This investigation will meticulously analyse the temporal and spatial attributes of rainfall, taking into account various factors including intensity and duration. The objective of this analysis is to identify appropriate water harvesting techniques that are specifically adapted to the distinctive characteristics of rainfall events occurring within the region (Helmreich & Horn). By elucidating the subtleties of rainfall variability, this research seeks to propose suitable techniques that correspond to the intensity and duration of precipitation events (Thomas et al. 2007)). This methodological approach guarantees the formulation of targeted and efficacious water harvesting strategies capable of alleviating the adverse effects of unpredictable rainfall patterns on water resources in the Tikamgarh district (Mustaq & Farjana 2015). The research will undertake a thorough evaluation of the soil types prevalent in the Tikamgarh district, scrutinizing their compositional and permeability characteristics. This analytical endeavour is essential for ascertaining the most suitable water harvesting methodologies, as it acknowledges that various techniques may demonstrate differing levels of effectiveness based on soil properties (Vogel et al. 2000). The investigation will specifically address the permeability of soils, distinguishing between sandy and clayey compositions. The permeability characteristics of the soil have a direct impact on water infiltration rates and drainage capacities. Consequently, comprehending these soil-specific attributes will inform the selection of water harvesting techniques that correspond with the unique characteristics of Tikamgarh's diverse soil types, thereby ensuring optimal effectiveness and sustainability in water management practices (Agassi et al. 1981). The study will rigorously evaluate the topography and terrain of the Tikamgarh district to identify locations that are conducive to particular water harvesting techniques. The investigation will take into consideration elements such as elevation, slope, and landform characteristics, acknowledging that the efficacy of water harvesting methods can be affected by topographical features (Kadam et al.2012). For example, regions characterized by sloping terrain may be recognized as suitable for contour trenching, a technique that capitalizes on the natural flow of water. By aligning water harvesting strategies with the topographical attributes of the region, this research aims to enhance the selection and implementation of techniques, ensuring their appropriateness and effectiveness in addressing water scarcity challenges in the Tikamgarh district (Sekar & Randhir 2007). This research will prioritize community engagement, recognizing the importance of social and cultural dimensions within local communities in the Tikamgarh district. This methodology entails the active involvement of stakeholders in the decision-making process regarding water harvesting techniques. By integrating the perspectives, needs, and preferences of community members, this study aims to ensure that the chosen techniques are congruent with their socio-cultural context. Through collaborative decision-making, the research aspires to cultivate a sense of ownership and

commitment among the local populace, thereby enhancing the feasibility and sustainability of water harvesting initiatives. This inclusive strategy acknowledges the critical role of community input in shaping effective and culturally relevant water management strategies in the Tikamgarh district (Jain & Jain 2020). The research will systematically evaluate the cost-effectiveness of implementing various water harvesting methods within the Tikamgarh district.

This evaluation will involve a meticulous examination of the preliminary investment necessary, continuous maintenance expenditures, and prospective returns linked to each technique. Crucially, the investigation will take into account the financial capabilities of local communities and the accessibility of resources, thereby ensuring a pragmatic and sustainable methodology towards water harvesting. Through the inclusion of economic viability considerations, the research aspires to deliver recommendations that correspond with the financial capacities of the communities, thereby optimizing resource allocation and enhancing the long-term sustainability of water harvesting initiatives in Tikamgarh. This approach highlights the significance of harmonizing environmental goals with economic factors for the effective execution of water management strategies. The study will rigorously evaluate the ecological ramifications of each water harvesting technique, acknowledging the necessity to prioritize approaches that mitigate detrimental impacts on the local ecosystem within the Tikamgarh district. This analysis will take into account variables such as soil health, biodiversity, and the sustainability of water resources. By prioritizing ecologically-sound techniques, the research aims to advocate for water harvesting methodologies that are consistent with principles of ecological conservation, thereby promoting the resilience of local ecosystems. The objective is to achieve a harmonious balance between addressing the challenges of water scarcity and preserving the environmental integrity of Tikamgarh, ensuring that the chosen methods contribute positively to the overall ecological well-being of the region. By synthesizing these research methodologies and considerations, the study seeks to furnish a comprehensive understanding of the water circumstances in the Tikamgarh district and to propose contextually relevant water harvesting techniques for sustainable and efficacious drought mitigation.

Significance of Water Harvesting in Tikamgarh District

A. Present Water Status in Tikamgarh District

The Tikamgarh district, located in the arid region of Maharashtra, encounters substantial difficulties pertaining to water scarcity. The current water status in the district can be characterized by: Tikamgarh contends with irregular and insufficient precipitation, a phenomenon that contributes to persistent droughts and water deficits within the region. The district's susceptibility to climatic fluctuations is intensified by its heavy dependence on monsoons for agricultural endeavors. The unpredictable nature of precipitation presents a considerable challenge to water availability and agricultural sustainability in Tikamgarh, thereby necessitating the formulation of comprehensive strategies for water resource management and drought alleviation to bolster resilience amid climatic uncertainties (Garg et al. 2020). The Tikamgarh district is confronted with a critical predicament of declining groundwater levels, which can be attributed to excessive extraction for both agricultural and domestic purposes. This overexploitation has resulted in the degradation of aquifers, further compounding the challenges associated with water availability, particularly during prolonged dry spells. The diminishing water tables represent an urgent concern, highlighting the imperative for sustainable water management practices and effective groundwater replenishment strategies to combat the escalating threats to the region's water security(Mustaq & Farjana 2015). The Tikamgarh district relies on surface water resources, such as rivers and lakes, as essential components of its water supply. Nevertheless, the existing resources are inadequate to satisfy the growing demand, which is exacerbated by population expansion and evolving consumption patterns. Moreover, these surface water sources are prone to seasonal variability, which affects their reliability, and are at risk of pollution. The interplay of limited availability, seasonal fluctuations, and pollution threats emphasizes the critical need for integrated water resource management strategies. Addressing these challenges necessitates a comprehensive approach that encompasses sustainable utilization, conservation initiatives, and effective pollution control measures to ensure the resilience and long-term sustainability of surface water resources in Tikamgarh.

B) Impact of drought on agriculture, livelihoods and Economy.

The phenomenon of drought-induced water scarcity within the Tikamgarh district frequently necessitates the migration of communities in search of water resources and employment opportunities. This involuntary displacement disrupts established social frameworks, thereby exerting additional pressure on urban environments and exacerbating vulnerability and poverty levels. The complex interrelationship among

water scarcity, migration, and socio-economic disruptions accentuates the imperative for comprehensive strategies that tackle the fundamental causes of drought, thereby enhancing the resilience of rural communities and alleviating the associated socio-economic challenges present in Tikamgarh(Miyan M 2015) Given the significant role that the agricultural sector plays in the economic framework of Tikamgarh district, the impacts of drought reverberate across multiple sectors. The reduction in agricultural productivity not only adversely affects the income levels of the farming community but also precipitates an increase in unemployment rates, serving as a barrier to the overall economic development of the region. The interconnected nature of the agricultural sector with broader economic activities highlights the paramount importance of instituting effective water management strategies to mitigate the detrimental economic consequences of drought in Tikamgarh.

C) Role of waterharvesting in improving water availability

The Significance of Water Harvesting in Enhancing Water Availability Water harvesting methodologies, encompassing rooftop rainwater collection and the implementation of check dams, assume a critical function in the enhancement of groundwater recharge within the Tikamgarh district (Mustaq et al. 2019). Through the collection and intentional infiltration of precipitation, these techniques substantially contribute to the replenishment of groundwater aquifers. This methodology aids in the sustenance of a reliable and sustainable water supply by reinforcing the water table, alleviating the consequences of over-extraction, and fostering the resilience of local water resources amidst erratic rainfall patterns and extended drought conditions. The integration of water harvesting methodologies, especially techniques such as contour trenching and percolation pits, serves to augment soil moisture levels in the Tikamgarh district. These techniques adeptly reduce surface runoff by promoting the gradual infiltration of water into the soil matrix. Consequently, they play a significant role in enhancing the moisture retention capacity of the soil, thereby creating a more favourable environment for optimal agricultural yield. This methodology highlights the essential relationship between water management practices and agricultural productivity, thereby advocating for sustainable farming methodologies within the region. Water harvesting initiatives function as an essential safeguard against the detrimental effects of drought by creating reserves of water. The accumulated rainwater from harvesting operations can be judiciously employed for irrigation during arid spells, thus ensuring continuity in agricultural endeavours and reducing crop susceptibility to hydric stress.

This pre-emptive water management strategy not only protects agricultural productivity but also fortifies the resilience of rural communities in Tikamgarh district, equipping them to confront the challenges presented by variable rainfall patterns and extended durations of water scarcity. The active engagement of local populations in the conceptualization and execution of water harvesting programs cultivates resilience at the community level in Tikamgarh district. Empowering residents to assume a vital role in the stewardship and conservation of water resources not only augments their sense of ownership but also guarantees the long-term viability of water availability. This community-oriented approach not only addresses pressing water scarcity issues but also contributes to the development of robust, self-sufficient communities capable of adapting to evolving environmental conditions and sustaining their water resources over time (Dungumaro & Madulu 2003). In summary, the significance of water harvesting in the Tikamgarh district is profoundly critical. The adoption of effective water harvesting techniques represents not merely a reaction to the present water crisis but also a proactive strategy for fostering resilience against future droughts, thereby securing agricultural viability, livelihoods, and the overall economic stability of the region.

Water harvesting Techniques

A. Rooftop Rainwater Harvesting

The methodology of rooftop rainwater harvesting encompasses the systematic collection of atmospheric precipitation from rooftops, directing the harvested rainwater through a network of gutters and pipes, and subsequently storing it in either tanks or subterranean reservoirs, thereby presenting a methodologically rigorous and efficacious approach to sustainable water management in the Tikamgarh district. The rooftop rainwater harvesting technique is relevant for both urban and rural settings within the Tikamgarh district, enabling individual households and small communities to effectively capture rainwater for both domestic and agricultural purposes. The inherent simplicity of this method renders it economically viable and readily implementable, in alignment with the socio-economic framework of the region and offering a plausible strategy for enhancing water resources in a scientifically substantiated manner. The extensive implementation of rooftop rainwater harvesting in Bangalore, India, has produced tangible results, including increased groundwater levels and improved water accessibility for both urban and rural populations. This case study

highlights the effectiveness of the employed strategy in alleviating water scarcity issues through scientifically informed water management methodologies (Singh & Turkiya 2017).

B. Check Dam

Check dams, defined as diminutive, low-lying structures erected across rivers or streams, serve to attenuate water flow, thereby facilitating sedimentation processes. This mechanism not only contributes to the recharging of groundwater but also acts as an efficient measure in curtailing soil erosion, thereby underscoring the scientifically grounded rationale of check dams in sustainable water resource management. Considering the river and stream network within the Tikamgarh district, the strategic deployment of check dams is deemed appropriate, as they can be judiciously positioned to capture rainwater during the monsoon season. This application is methodologically sound, as check dams are demonstrably effective in enhancing groundwater recharge and alleviating downstream flooding, providing a localized and sustainable approach to water resource management in the region. The establishment of check dams in the Ralegan Siddhi village of Maharashtra has exemplified a transformative influence on the landscape, scientifically evidenced by increased water availability for agricultural endeavors, reduced soil erosion, and an overall enhancement in water management practices. This case study reinforces the effectiveness of check dams as a sustainable strategy for the augmentation of water resources and the promotion of ecosystem resilience in analogous agro-ecological frameworks (Tang et al. 2019).

C. Contour Trenching

The technique entails the excavation of trenches that align with the natural contours of the terrain, thereby serving to capture and attenuate surface water runoff. This methodology is scientifically endorsed as it enhances infiltration, thereby promoting the penetration of water into the soil, while simultaneously functioning as an effective strategy to avert soil erosion. Specifically designed for the undulating topography of the Tikamgarh district, contour trenching is aptly suited as it proficiently conserves rainwater through the facilitation of percolation into the soil profile. This empirically grounded approach has demonstrated effectiveness in improving soil moisture levels, consequently fostering an environment that is conducive to the implementation of rainfed agricultural practices within the region (Adhikary et al. 2017). The successful execution of contour trenching by the Watershed Organization Trust (WOTR) across various regions, including Maharashtra, has been characterized by a rigorously substantiated impact, leading to increased agricultural productivity and enhanced water availability. This case study highlights the efficacy of contour trenching as a significant watershed management strategy with prospective applications for promoting sustainable agriculture and enhancing water resources in comparable geographical settings. D. Percolation Pits Percolation pits, defined as diminutive excavated structures filled with coarse materials, are engineered to facilitate the regulated infiltration of rainwater into the subsurface, thereby presenting a scientifically informed technique for augmenting groundwater recharge and alleviating surface runoff (Motiee & McBean 2017). Within the context of the Tikamgarh District, percolation pits, due to their adaptability to limited spatial conditions, can be strategically deployed to capture runoff and efficiently recharge groundwater resources. This method, grounded in scientific rationale, is particularly beneficial in urban and peri-urban environments, providing a localized and sustainable solution for the enhancement of water resources in the region. The application of percolation pits by the Tarun Bharat Sangh in Rajasthan, India, serves as a significant case study illustrating how the revival of traditional water-harvesting structures has scientifically contributed to increased groundwater levels and improved water availability for agricultural endeavors. This demonstrates the effectiveness of percolation pits as a sustainable approach to the management of water resources in arid regions, with potential ramifications for similar agro-ecological contexts.

D.Farm Ponds

Farm ponds, characterized as diminutive reservoirs intentionally constructed within agricultural landscapes, function as essential elements for the collection and retention of precipitation, thereby systematically enabling its employment for irrigation purposes. This methodology is congruent with empirically substantiated strategies aimed at enhancing water accessibility within agricultural contexts, thereby contributing to the sustainable and efficient management of water resources (Rao et al. 2017). Within the geographical confines of Tikamgarh District, farm ponds present themselves as an optimal solution for increasing water accessibility in farming regions. From a scientific perspective, these reservoirs proficiently accumulate rainwater during the monsoon season, providing a strategic framework for subsequent irrigation practices. This methodology alleviates dependence on traditional water sources, fostering a sustainable and scientifically validated approach to agricultural water management within the area. The successful advocacy for the establishment of farm ponds by the Watershed

Development Project in Madhya Pradesh represents a significant case study, wherein the actualization of these reservoirs has empirically resulted in improved water accessibility and a subsequent enhancement of crop yields, thereby underscoring the effectiveness of such methodologies in the sustainable management of watersheds. These water conservation techniques, when implemented judiciously and synergistically, proffer a holistic strategy for confronting water scarcity challenges in the Tikamgarh district. Documented successful case studies illustrate the potential for substantial beneficial impacts on water availability, agricultural productivity, and the overall resilience of the community.

A. Enhanced Water Accessibility-

The implementation of water harvesting methodologies, encompassing rooftop rainwater collection, check dams, and percolation pits, plays a critical role in augmenting groundwater recharge (Mustaq et al. 2015) Furthermore, these methodologies yield improvements in soil moisture retention, thereby extending the duration of water availability for agricultural crops. From a scientific perspective, this comprehensive approach highlights the efficacy of diverse strategies in promoting sustainable water management, thereby favourably influencing both groundwater reserves and agricultural output. The resultant effects include a significant decrease in dependence on erratic precipitation patterns, thereby guaranteeing a more reliable water supply for agricultural and domestic uses. Consequently, this has led to an increased resilience to periods of drought and arid conditions, thus facilitating sustained agricultural productivity. Scientifically, these beneficial outcomes emphasize the effectiveness of deploying water harvesting techniques in alleviating the susceptibility of the area to climatic fluctuations and bolstering overall water security.

B. Sustainable Agricultural Practices

The execution of water harvesting strategies guarantees adequate water availability for irrigation, particularly during pivotal growth phases of crops, thereby scientifically optimizing agricultural yield. Concurrently, this methodology diminishes reliance on traditional water sources, thereby alleviating the adverse effects of water scarcity on agricultural operations. The scientifically supported adoption of water harvesting techniques fosters sustainable and resilient agricultural frameworks, in accordance with the principles of effective water resource management. The observable results include enhanced crop yields and diversification of agricultural produce attributable to the provision of a reliable water supply facilitated by water harvesting practices. This progression has led to increased income for farmers and simultaneously improved food security within local communities. Scientifically, these favourable impacts highlight the effectiveness of sustainable water management approaches in enhancing agricultural resilience and socioeconomic prosperity in the region (Viessman W 1997).

Recommendationsfor implementing water Harvesting projects in Tikamgarh district

To successfully implement water harvesting projects in Tikamgarh District, it is essential to engage in comprehensive watershed assessments that identify optimal locations based on topography, soil characteristics, and rainfall patterns. This scientific approach ensures that areas with the highest potential for effective water retention are prioritized. Community engagement should be central to these projects, involving local residents throughout the planning, implementation, and maintenance phases. This inclusive strategy fosters community ownership and long-term sustainability by integrating local knowledge into decision-making. Collaboration among diverse stakeholders, including government agencies, NGOs, researchers, and local businesses, is crucial to mobilize resources and share expertise effectively.

Incorporating traditional water management practices into modern initiatives is also recommended, recognizing their cultural significance and enhancing community acceptance. Integrating these methods with contemporary techniques creates a balanced and culturally sensitive approach to water management. Educational programs should be strategically deployed to raise awareness about water harvesting and its benefits, with outreach targeting schools, community centres, and local gatherings. Financial incentives, such as subsidies or grants, can be provided to reduce the initial cost burden and promote the widespread adoption of water harvesting systems.

Furthermore, it is vital to formulate and enforce water conservation policies that encourage responsible water use, such as regulations mandating water harvesting systems in new constructions and agricultural areas. Regular monitoring and evaluation mechanisms should be established to assess the impact of projects on groundwater levels, agricultural productivity, and community resilience, ensuring continuous improvement based on evidence. Additionally, resources should be allocated to research and development, supporting pilot projects that explore innovative water harvesting techniques suited to Tikamgarh's specific conditions.

To ensure long-term resilience, water harvesting infrastructure must be designed with considerations for

changing rainfall patterns and extreme weather events, aligning with climate adaptation principles. Finally, training programs targeting local technicians and community members should be implemented to build technical capacity for effective project maintenance. Through this multi-faceted approach, Tikamgarh District can strengthen its water security and resilience against drought.

Conclusion

The research on water harvesting techniques for drought mitigation in Tikamgarh district highlights the significance of these strategies in enhancing water availability and fostering resilience against water scarcity. Tikamgarh's current water situation is characterized by irregular rainfall patterns, declining groundwater levels, and limited surface water resources, with prolonged droughts severely impacting agriculture, livelihoods, and the local economy. The study explored a variety of water harvesting techniques, such as rooftop rainwater harvesting, check dams, contour trenching, percolation pits, and farm ponds. Each technique has specific advantages suited to Tikamgarh's geographical and climatic conditions, offering promising results in improving water availability and supporting sustainable agricultural practices.

Community engagement emerged as a crucial factor in ensuring the long-term sustainability of these projects. Involving local communities in decision-making and implementation enhances cultural relevance and fosters commitment. Successful water harvesting practices not only help address water scarcity but also contribute to broader goals such as environmental conservation, economic growth, and resilience against climate change.

The research findings suggest that water harvesting techniques can have far-reaching impacts beyond Tikamgarh. By demonstrating effective ways to capture and utilize rainwater, these methods can inspire similar efforts in other arid and semi-arid regions facing water scarcity. The study underscores the importance of adopting a holistic approach that links water conservation, agricultural sustainability, economic development, and community well-being. Through the implementation of water harvesting initiatives, Tikamgarh has the potential to lead by example in achieving water security and resilience, influencing regional and national policies for sustainable water management.

Refrences-

1. Adhikary, P., Hombegowda, H., Barman, D., Jakhar, P., & Madhu, M. (2017). Soil erosion control and carbon sequestration in shifting cultivated degraded highlands of eastern India: performance of two contour hedgerow systems. Agroforestry Systems, 91, 757-771.
2. Agassi, M., Shainberg, I., & Morin, J. (1981). Effect of Electrolyte Concentration and Soil Sodicity on Infiltration Rate and Crust Formation. Soil Science Society of America Journal, 45, 848-851.
3. Dile, Y., Karlberg, L., Temesgen, M., & Rockström, J. (2013). The role of water harvesting to achieve sustainable agricultural intensification and resilience against water related shocks in sub-Saharan Africa. Agriculture, Ecosystems & Environment, 181, 69-79.
4. Domènech, L., & Saurí, D. (2011). A comparative appraisal of the use of rainwater harvesting in single and multi-family buildings of the Metropolitan Area of Barcelona (Spain): social experience, drinking water savings and economic costs. Journal of Cleaner Production, 19, 598-608.
5. Dungumaro, E., & Madulu, N. (2003). Public participation in integrated water resources management: the case of Tanzania. Physics and Chemistry of The Earth, 28, 1009-1014.
6. Garg, K., Singh, R., Anantha, K., Singh, A., Akuraju, V., Barron, J., Dev, I., Tewari, R., Wani, S., Dhyani, S., & Dixit, S. (2020). Building climate resilience in degraded agricultural landscapes through water management: A case study of Bundelkhand region, Central India. Journal of Hydrology, 591, 125592.
7. Grewal, S., Mittal, S., Agnihotri, Y., & Dubey, L. (1989). Rainwater harvesting for the management of agricultural droughts in the foothills of northern India. Agricultural Water Management, 16, 309-322
8. Helmreich, B., & Horn, H. (2009). Opportunities in rainwater harvesting. Desalination, 248, 118-124.
9. Jain, P., & Jain, P. (2020). Viewpoint: Defeating the water crisis: Community matters!. Local Economy: The Journal of the Local Economy Policy Unit, 35, 539-544.
10. Kadam, A., Kale, S., Pande, N., Pawar, N., & Sankhua, R. (2012). Identifying Potential Rainwater Harvesting Sites of a Semi-arid, Basaltic Region of Western India, Using SCS-CN Method. Water Resources Management, 26, 2537-2554.

11. Miyan, M. (2015). Droughts in Asian Least Developed Countries: Vulnerability and sustainability. Weather and climate extremes, 7, 8-23.
12. Mustaq Shaikh, Farjana Birajdar. (2015). Analysis of watershed characteristics using remote sensing and GIS techniques. International Journal of Innovative Research in Science, Engineering and Technology.
13. Mustaq Shaikh, Farjana Birajdar. (2015). Anticipation of Water Scarcity Impacted Areas and Duration: A Case Study of Osmanabad District, Maharashtra, India. International Journal of Latest Technology in Engineering, Management & Applied Science, vol. 4, no. 3, 1-5.
14. Mustaq Shaikh, Herlekar, M. A. and Umrikar B. N. (2016) Evaluation of Multiple Hydrometeorological Factors for Prioritization of Water Stress Areas in the Upper Yerala River Basin, Satara, Maharashtra, India., Springer International Publishing, In: Pawar P., Ronge B., Balasubramaniam R., Seshabhattar S. (eds) Techno-Societal 2016. ICATSA 2016. Springer, Cham.
15. Mushtaq, S., Khan, S., & Hafeez, M. (2009). Evaluating the impact of ponds in sustaining crop production: a case of Zhanghe irrigation system in China. Water Policy, 11, 236-249.
16. Mustaq Shaikh, Farjana Birajdar. (2023). GIS-based multi-criteria evaluation techniques for demarcation of solid waste disposal site locations in Tikamgarh city, Maharashtra, India. International Journal of Novel Research and Development, vol. 8, no. 4, April 2023
17. Pathare, D., Panaskar, D., Wagh, V., Salunkhe, S., & Pawar, R. (2021). Classification of Groundwater Quality for Drinking Purpose Concerning Industrial Effluent from Akkalkot MIDC, Tikamgarh, Maharashtra, India. Techno-Societal 2020.
18. Rao, C., Rejani, R., Rao, C., Rao, K., Osman, M., Reddy, K., Kumar, M., & Kumar, P. (2017). Farm Ponds for Climate-Resilient Rainfed Agriculture. Current Science, 112, 471.
19. Sekar, I., & Randhir, T. (2007). Spatial assessment of conjunctive water harvesting potential in watershed systems. Journal of Hydrology, 334, 39 52.
20. Singh, R., & Kumar, A. (2015). Climate variability and water resource scarcity in drylands of Rajasthan, India. Geoenvironmental Disasters, 2, 1-10.
21. Singh, O., & Turkiya, S. (2017). Assessing Potential for Rooftop Rainwater Harvesting: An Option for Sustainable Rural Domestic Water Supply in Arid Region of Haryana. Journal of Rural and Development, 36, 49-60.
22. Thomas, D., Twyman, C., Osbahr, H., & Hewitson, B. (2007). Adaptation to climatechange and variability: farmer responses to intra-seasonal precipitation trends in South Africa. Climatic Change, 83, 301-322.
23. Viessman, W. (1997). Integrated Water Management. Journal of Contemporary Water Research & Education, 106, 2.
24. Vogel, T., Gerke, H., Zhang, R., & Genuchten, M. (2000). Modeling flow and transport in a two-dimensional dual-permeability system with spatially variable hydraulic properties. Journal of Hydrology, 238, 78-89.

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Economice Benefits of Agro-Waste Valorization for Farmers

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ABSTRACT

Agro-waste valorization offers a sustainable solution to address agricultural waste management while unlocking significant economic benefits for farmers. This process involves converting agricultural residues such as crop stalks, husks, peels, and other organic materials into valuable products like biofuels, organic fertilizers, animal feed, and bioplastics. By adopting agro-waste valorization, farmers can diversify their income streams, reduce input costs, and access emerging eco-friendly markets. In addition to financial gains, agro-waste valorization mitigates environmental challenges by reducing waste disposal costs, preventing harmful practices like open burning, and promoting a circular economy. This approach enhances resource efficiency, aligns with global sustainability goals, and positions farmers as key contributors to green innovation.This paper explores the economic potential of agro-waste valorization for farmers, highlighting its role in improving profitability, fostering resilience, and supporting sustainable agricultural development.

1. Introduction

Agro-waste, the byproduct of agricultural activities, has traditionally been considered a disposal challenge. However, with growing awareness of sustainable practices and advancements in technology, agro-waste valorization has emerged as a transformative solution that converts this waste into valuable resources. Agro-waste includes crop residues, fruit and vegetable peels, husks, shells, and other organic materials, which, when effectively utilized, can significantly enhance the economic well-being of farmers[1].The economic benefits of agro-waste valorization are multifaceted. By turning waste into products such as biofuels, organic fertilizers, animal feed, or bioplastics, farmers can diversify their income streams and reduce their dependency on conventional market crops. This process not only adds value to what was once considered refuse but also lowers production costs by providing affordable alternatives to synthetic inputs[2].

Moreover, agro-waste valorization contributes to a circular economy, where resources are reused and recycled, reducing waste and environmental impact. Farmers can capitalize on the increasing demand for eco-friendly products, gaining access to new markets and opportunities for premium pricing. Additionally, the integration of agro-waste valorization practices can reduce waste disposal costs and minimize the negative effects of open burning or landfilling, aligning with sustainable farming practices and regulations[3].By adopting agro-waste valorization techniques, farmers can boost profitability, improve resource efficiency, and contribute to environmental conservation, ultimately fostering a more resilient and sustainable agricultural sector[4].

1.1 Importance of Agriculture in the Global Economy

Agriculture is the backbone of the global economy, providing food, raw materials, and employment for billions worldwide. It contributes significantly to the GDP of many nations, especially in developing countries, where a substantial portion of the population depends on farming for their livelihoods. According to the World Bank, agriculture accounts for approximately 4% of global GDP, and in some developing countries, it can contribute more than 25%ctor is vital for food security, as it ensures the production of staple crops and livestock to sustain the growing global population, projected to reach nearly 10 billion by 20505. Moreover, agriculture supports related industries such as food processing, trade, and transportation, creating multiplier effects that drive economic growth. It is also a key player in achieving several United Nations Sustainable Development Goals (SDGs), including eradicating hunger, reducing poverty, and promoting sustainable use of resources.

1.2 Agricultural Waste and Its Impact on the Environment

Despite its critical importance, agriculture generates significant waste, posing a severe environmental challenge. Agricultural waste includes crop residues (such as straw, husks, and stalks), animal manure, and by-products from food processing. It is estimated that the world produces billions of tons of agricultural waste annually, with much of it either burned or left to decompose, contributing to environmental degradation. Improper management ofleads to greenhouse gas emissions, primarily methane and nitrous oxide, which exacerbate climate change. The open burning of crop residues is a widespread practice in many regions, releasing harmful pollutants like carbon dioxide,

particulate matter, and black carbon into the atmosphere. In addition, runoff from improperly managed manure and agricultural by-products can contaminate water sources, causing eutrophication and harming aquatic ecosystems[6].

1.3 Definition of Agro-Waste Valorizationotential

Agro-waste valorization refers to the process of converting agricultural residues and by-products into valuable resources such as bioenergy, biofertilizers, bioplastics, and other industrial raw materials. This approach not only mitigates environmental impacts but also offers economic opportunities by creating value-added products[7].

The potential of agro-waste valorization lies in ito transform a problem into a solution. For instance, agricultural residues can be converted into biofuels, reducing reliance on fossil fuels and lowering carbon emissions. Manure and crop residues can be composted into organic fertilizers, promoting sustainable farming practices. Innovations such as bioplastics derived from agricultural by-products offer environmentally friendly alternatives to conventional plastics, helping to reduce pollution[8].

Furthermore, agro-waste valorization can enhance rural livew revenue streams for farmers and supporting local industries. It also aligns with circular economy principles, ensuring that resources are reused and recycled to minimize waste. With advancing technology and supportive policies, agro-waste valorization has the potential to address both environmental and economic challenges, making it a cornerstone of sustainable agricultural practices in the 21st century[9].

2. Types of Agricultural Waste and Its Implications

Agricultural waste is a significant by-product of farming and associated industries, generated at multiple stages from cultivation to processing. Its proper management is crucial for sustainable development and environmental conservation. The major types of agricultural waste are as follows:

2.1. Crop Residues

Crop residues consist of plant materials left behind after harvesting, such as straw, husks, stalks, leaves, and shells. These residues are abundant and vary widely depending on the type of crop and farming practices. For example, rice husks, wheat straw, and corn stalks are common by-products.

Global Generation: Crop residues constitute a major portion of agricultural waste globally, with countries like India producing approximately 620 million tons annually[10].

2.2. Animal Waste

Animal waste includes manure, urine, and other residues from livestock rearing, such as dairy, poultry, and aquaculture farming. This waste is rich in organic matter and nutrients but is often underutilized.

Global Impact: The global livestock industry generates an estimated 3.1 billion tons of manure annually, making it one of the most substantial contributors to agricultural waste[11, 12] .

2.3. Food Processing By-products

Food processing activities generate by-products such as fruit peels, seed shells, molasses, and pulp. These residues often go unused despite their potential for value-added products like biofuels or fertilizers.

Economic Loss: It is estimated that 14% of the world's food production is lost during post-harvest and processing stages (United Nations)[13, 14] .

2.4. Spoiled or Rejected Produce

Agricultural produce that fails to meet market standards due to spoilage, blemishes, or improper handling often goes to waste. This contributes to significant food loss, exacerbating issues of food insecurity and environmental degradation.

2.5. Agro-Industrial Waste

By-products from agro-industrial activities, such as sugar, dairy, and palm oil production, include bagasse, whey, and palm kernel shells. These materials are often discarded or used inefficiently, missing opportunities for resource recovery.

2.6. Plastic and Packaging Waste

Modern farming practices involve the use of plastic films, netting, and containers, which contribute to non-biodegradable waste. This type of waste is challenging to manage and has long-term environmental impacts.

3. Quantitative Data on Agro-Waste Generation Globally

The world produces approximately 5 billion tons of agricultural biomass waste annually[15,16]. India alone generates around 620 million tons of crop residues yearly, a significant portion of which is burned, releasing harmful emissions[17,18].The livestock sector contributes 3.1 billion tons of animal manure, which, if managed effectively, can serve as a resource for bioenergy and fertilizers[19,20]. Approximately 14% of global food production is lost during post-harvest and processing stages, contributing significantly to agricultural waste[21].

3.1 Current Practices of Agro-Waste Disposal and Their Limitations

3.1.1. Open Burning

Open burning of crop residues is a prevalent method of disposal, especially in developing countries

like India and China. Farmers often resort to this practice due to a lack of alternatives and economic constraints.

*** Limitations**

* Releases greenhouse gases (CO_2, methane) and pollutants like particulate matter and black carbon.
* Contributes to severe air quality issues, such as smog, affecting human health and ecosystems.

3.1.2. Dumping in Landfills

Manure, spoiled produce, and agro-industrial waste are frequently dumped in landfills, occupying valuable land and creating environmental hazards.

* Limitations
* Decomposition in landfills generates methane, a potent greenhouse gas.
* Nutrients that could improve soil fertility are lost, creating inefficiencies in resource management.

3.1.3. Uncontrolled Decomposition

In some cases, animal waste and crop residues are left to decompose in fields or storage areas without proper management.

* Limitations
* Leads to unpleasant odors and attracts pests, posing health risks to nearby communities.

o Releases greenhouse gases like methane and nitrous oxide during decomposition, exacerbating climate change.

3.1.4. Low-Value Uses

Agricultural waste is sometimes used as low-grade animal feed or inefficient fuel, particularly in rural areas.

* Limitations

* Does not fully utilize the economic potential of agricultural residues.
* Results in missed opportunities to produce higher-value products like bioenergy, biofertilizers, or bioplastics.

3.1.5. Minimal Recycling or Reuse

Inadequate infrastructure for recycling or reusing agricultural by-products is a common issue in many regions.

* Limitations

* Wastes valuable resources that could be converted into renewable energy or industrial raw materials.
* Fails to align with circular economy principles, perpetuating resource inefficiencies.

4. Impacts of Inefficient Agro-Waste Disposal

The improper management of agricultural waste has far-reaching consequences for the environment and the economy:

1. Environmental Impact

* Emissions from burning and decomposition contribute significantly to climate change.
* Landfills and improper waste management contaminate soil and water sources, affecting biodiversity.

2. Economic Loss

* Wasted agricultural by-products represent missed opportunities for farmers to generate additional income.
* Costs associated with health issues and environmental degradation add to the financial burden on communities and governments.

4.1. Economic Benefits for Farmers: Cost Savings

Effective agro-waste valorization provides substantial cost-saving opportunities for farmers by reducing waste management expenses and minimizing dependence on costly agricultural inputs. These savings not only improve farmers' financial resilience but also promote environmentally sustainable practices.

4.1.1 Reduction in Waste Disposal Costs

The traditional methods of agricultural waste disposal, such as open burning, landfilling, or uncontrolled decomposition, often come with significant costs. These include labor, transportation, and compliance with environmental regulations, where applicable. Agro-waste valorization eliminates or significantly reduces these costs by turning waste into resources.

* Open Burning and Its Costs

Open burning of crop residues is a common disposal method but involves labor costs and leads to fines or penalties in regions with strict environmental laws. Avoiding this practice through valorization not only cuts expenses but also improves air quality and reduces health-related costs for farming communities.

*** Landfilling Expenses**

For farms that rely on landfills, disposal involves transportation and tipping fees, which can be a financial burden, especially for large-scale operations. Utilizing waste for composting or bioenergy avoids these costs and creates economic value instead.

Example : In India, the adoption of decentralized composting units for crop residues has saved smallholder farmers up to 20% of annual waste management costs, while reducing pollution from burning[22,23].

4.1.2 Savings on Fertilizers and Other Inputs Through **Composting**

Composting converts organic agricultural waste, such as crop residues and animal manure, into nutrient-rich compost, which serves as an effective and affordable alternative to chemical fertilizers.

* Reduction in Fertilizer Costs

By producing their own compost, farmers can save on the purchase of synthetic fertilizers, which are often expensive and subject to price volatility. Compost provides essential nutrients, improves soil health, and enhances water retention, reducing the need for additional inputs.

* Environmental and Long-Term Savings

Continuous use of compost improves soil fertility over time, reducing dependency on chemical inputs. This creates a sustainable farming cycle and mitigates environmental degradation caused by overuse of synthetic fertilizers.

4.2 Economic Benefits for Farmers: Revenue Generation

Agro-waste valorization provides farmers with new revenue streams by enabling the production and sale of value-added products and creating opportunities to participate in carbon credit markets. These avenues enhance the profitability of farming operations while contributing to environmental sustainability.

4.2.1 Selling Value-Added Products

Agro-waste can be transformed into various high-demand, value-added products such as biofertilizers, biofuels, and biogas. These products serve diverse industries, ranging from agriculture to energy and manufacturing, creating lucrative markets for farmers.

1. Biofertilizers

* Composting or anaerobic digestion processes convert organic waste into biofertilizers, which can be sold locally or in larger markets.
* These organic alternatives to chemical fertilizers are increasingly popular among eco-conscious consumers and sustainable agriculture initiatives.

Example: Farmers producing vermicompost from crop residues in India generate an additional income of $300-$500 annually per acre, depending on local market demand[24].

2. Biofuels and Biogas

* Biofuels like biodiesel (from oilseed waste) and ethanol (from sugarcane bagasse) offer alternative energy sources that are renewable and eco-friendly.
* Biogas plants convert organic waste, including manure and crop residues, into biogas for cooking, heating, or electricity generation. Excess energy or by-products such as digestate (organic fertilizer) can be sold.

Example: In Germany, farmers with biogas plants generate annual revenues of $20,000-$30,000 by selling electricity back to the grid[25].

4.2.2 Income from Carbon Credits in Sustainable Farming

Sustainable farming practices that involve agro-waste valorization often reduce greenhouse gas emissions, qualifying farmers to earn carbon credits. These credits can be traded on carbon markets, offering a significant revenue source.

1. How It Works

* Farmers using biochar, composting, or biogas technologies reduce carbon dioxide, methane, and nitrous oxide emissions, earning credits for each ton of greenhouse gas mitigated.
* Carbon credits are sold to industries or governments seeking to offset their emissions.

* **Economic Potential :** The value of carbon credits varies depending on global markets, but prices can range from $5 to $50 per ton of CO_2 equivalent reduced[26].

Example:A farmer in Brazil practicing no-burn agriculture and composting on 50 hectares earns approximately $10,000 annually from carbon credit sales[27].

2. Programs Supporting Farmers

* International schemes like the Clean Development Mechanism (CDM) and voluntary carbon markets support farmers in accessing and monetizing carbon credits.
o Regional programs, such as the African Carbon Market Initiative, provide smallholder farmers with technical and financial assistance to participate.

4.3 Economic Benefits for Farmers: Employment Opportunities

Agro-waste valorization opens pathways for employment creation and entrepreneurial ventures, transforming agricultural waste management into a thriving economic sector. These opportunities contribute to rural development, reduce unemployment, and empower local communities through skill-building and income generation.

4.3.1 Jobs Created in the Agro-Waste Recycling and Processing Industry

The process of collecting, recycling, and converting agro-waste into value-added products requires a skilled and semi-skilled workforce, creating jobs at various levels of the value chain.

1. Collection and Logistics

* Employment opportunities are created for workers involved in the collection, sorting, and transportation of agro-waste from farms to processing facilities.
* Example: Farmers in Kenya have partnered with waste collection cooperatives, employing

hundreds to gather crop residues and fruit peels for compost production.

2. Processing Facilities

* Recycling plants and biogas units require technicians, machine operators, and maintenance staff for daily operations.
* Example: In India, biogas plants employ local workers for feedstock preparation, plant operation, and fertilizer distribution, supporting job creation in rural areas.

3. Distribution and Sales

* Workers are needed to package, market, and distribute biofertilizers, biofuels, and other value-added products to markets, creating jobs in retail and supply chain management.

Impact: Studies show that for every 1,000 tons of agro-waste processed, approximately 20-30 jobs are created across collection, processing, and sales functions, particularly in rural areas[28].

4.3.2 Opportunities for Entrepreneurship

Agro-waste valorization offers farmers and local entrepreneurs the chance to establish small-scale businesses focused on recycling and value-added production. These ventures stimulate local economies and provide sustainable income sources.

1. Composting and Vermiculture Businesses:

* Entrepreneurs can establish composting units to produce and sell organic fertilizers, catering to the growing demand for sustainable agricultural inputs.
* Example: Small-scale vermicompost businesses in the Philippines generate annual revenues of $5,000-$10,000, catering to local farming communities[29].

2. Biogas and Bioenergy Plants

* Farmers and cooperatives can invest in small-scale biogas plants to generate energy for local use and sell surplus electricity or by-products such as digestate.
* Example: In Nepal, community-owned biogas plants powered by cattle manure support energy needs and create revenue for rural entrepreneurs.

3. Production of Bioplastics and Eco-Friendly Products

* Agro-waste like corn starch, cassava, and sugarcane bagasse can be used to produce biodegradable packaging materials, tapping into the growing demand for sustainable alternatives to plastics.
* Example: Entrepreneurs in Thailand are capitalizing on cassava waste to manufacture bioplastics, exporting their products to global markets.

4. Customized Services

* Entrepreneurs can offer consulting, technology installation, and maintenance services for composting units, bioenergy systems, and waste processing equipment.

Impact: Agro-waste valorization entrepreneurship encourages innovation and self-reliance, enabling individuals to address environmental challenges while generating income.

4.4 Economic Benefits for Farmers

Agro-waste valorization not only provides direct economic benefits but also enhances productivity and expands market opportunities. These outcomes empower farmers to achieve sustainable agricultural growth and tap into lucrative eco-conscious markets.

4.4.1 Enhanced Productivity

1. Improving Soil Health Through Compost Use

* Compost, produced from agro-waste, enriches soil with essential nutrients, improves structure, and enhances water retention capacity. This leads to higher crop yields and reduces the need for chemical fertilizers.
* Nutrient Cycling: Compost returns valuable nutrients like nitrogen, phosphorus, and potassium to the soil, maintaining long-term fertility.
* Environmental Benefits: Compost reduces soil erosion and mitigates salinity issues, contributing to overall land sustainability.

Example: Farmers in Ethiopia using compost instead of synthetic fertilizers reported yield increases of up to 30% for crops like maize and wheat, with improved soil quality reducing input costs over time[30].

2. Benefits of Biochar and Organic Amendments

* Biochar: A carbon-rich product derived from the pyrolysis of agro-waste, biochar improves soil fertility by increasing microbial activity and nutrient retention while reducing greenhouse gas emissions.
* Organic Amendments: Residues such as green manure and vermicompost enhance soil biodiversity, increase organic matter content, and improve pH balance.

Example:In India, applying biochar to rice paddies has shown yield improvements of 10-15%, along with reduced water consumption and enhanced nitrogen efficiency[31].

4.4.2 Market Expansion

1. Access to Eco-Conscious Consumers

* The global shift toward sustainability has led to growing demand for eco-friendly and organic

agricultural products. Farmers engaged in agro-waste valorization can cater to these eco-conscious consumers and command premium prices.

* Organic Certification: Farmers using compost and biofertilizers for sustainable cultivation can obtain organic certification, which increases the marketability of their produce.

Example: Organic vegetables grown with composted fertilizers in the European market fetch prices that are 20-30% higher than those of conventionally grown produce[32].

2. Participation in the Circular Economy

* The circular economy emphasizes the reuse and recycling of resources. By transforming agro-waste into valuable products, farmers integrate into this sustainable economic model, reducing waste and creating additional income streams.
* Industrial Collaboration: Farmers can partner with industries that use agricultural residues for bioplastics, bioenergy, or textile manufacturing.
* Sustainability Branding: Products linked to circular economy practices can be marketed as environmentally responsible, broadening consumer appeal.

Example: Sugarcane farmers in Brazil supply bagasse to bioenergy companies, earning consistent income while contributing to renewable energy production.

5. Challenges and Limitations of Agro-Waste Valorization

Despite its numerous economic and environmental benefits, agro-waste valorization faces significant challenges and limitations that hinder its widespread adoption. These obstacles include financial constraints, a lack of technical knowledge, and inadequate policy support and infrastructure.

5.1 Financial Constraints for Small-Scale Farmers[33]

1. High Initial Investment

* Setting up facilities for agro-waste valorization, such as composting units, biogas plants, or pyrolysis systems for biochar, often requires significant capital. Small-scale farmers with limited resources may struggle to afford such investments.

2. Limited Access to Credit and Subsidies

* Many smallholder farmers lack access to affordable credit or government subsidies to fund the adoption of agro-waste management technologies. This is exacerbated by financial institutions' reluctance to support projects with perceived high risks and long payback periods.

3. Operational Costs

* Beyond initial setup, ongoing expenses for maintenance, labor, and transportation of agro-waste can burden farmers with constrained budgets, reducing the feasibility of valorization projects.

Example: In many parts of Sub-Saharan Africa, small-scale farmers cite high costs as the primary barrier to adopting biogas systems, which could otherwise provide sustainable energy and organic fertilizer.

5.2 Lack of Awareness and Technical Know-How[34]

1. Limited Knowledge About Valorization Benefits

* Many farmers are unaware of the economic potential and environmental benefits of agro-waste valorization, leading to continued reliance on traditional waste disposal methods like burning or dumping.

2. Technical Challenges

* Effective agro-waste processing often requires specialized knowledge and skills, such as composting techniques, biogas plant operation, or biochar production. In rural areas, access to training programs or technical support is often lacking.

3. Resistance to Change

* Farmers accustomed to conventional practices may be reluctant to adopt new methods due to skepticism about their effectiveness or a lack of visible short-term benefits.

Example: In India, despite government campaigns promoting composting, many farmers still burn crop residues due to ease and familiarity, despite the harmful environmental impacts.

5.3 Policy and Infrastructure Gaps[35]

1. Inadequate Policies and Incentives

* In many countries, policies supporting agro-waste valorization are either absent or insufficient. A lack of subsidies, tax benefits, or incentives discourages farmers from investing in waste management technologies.
* Weak enforcement of regulations against environmentally harmful practices like open burning further undermines progress.

2. Insufficient Infrastructure

* Rural areas often lack the infrastructure needed to support agro-waste collection, transport, and processing. Without access to nearby facilities, farmers are left with few practical options for valorization.

3. Lack of Market Linkages

* Farmers often struggle to connect with markets for value-added products, such as biofertilizers or biogas, reducing the financial viability of these initiatives.
* The absence of organized supply chains or cooperatives adds to logistical and operational challenges.

Example:In Southeast Asia, farmers face difficulties selling biogas-generated energy due to the absence of grid connectivity or power purchase agreements with local utilities.

6. Policy Recommendations for Promoting Agro-Waste Valorization

To unlock the full potential of agro-waste valorization, strategic policy interventions are essential. These include financial incentives, educational initiatives, improved market connectivity, and collaborative partnerships. These measures can empower farmers, address systemic challenges, and ensure sustainable agricultural practices.

6.1 Government Incentives and Subsidies[36]

1. Financial Support for Initial Investments

* Provide subsidies or low-interest loans to farmers for establishing composting units, biogas plants, or other agro-waste processing facilities.
* Example: India's National Biogas and Manure Management Programme (NBMMP) offers financial assistance to farmers for biogas plant installation.

2. Tax Benefits and Grants

* Introduce tax exemptions or grants for farmers and enterprises involved in agro-waste valorization.
* Support cooperative farming initiatives to pool resources and access financial assistance collectively.

3. Carbon Credit Programs

* Encourage farmers to adopt sustainable agro-waste practices by linking them to carbon credit markets. Governments can facilitate participation and simplify access to global carbon offset programs.

Impact: Incentives and subsidies reduce financial barriers, enabling smallholder farmers to adopt innovative waste valorization methods and derive economic benefits.

6.2 Training Programs for Farmers on Valorization Techniques[37]

1. Capacity Building

* Develop and implement training programs to educate farmers about the benefits and methods of agro-waste valorization, such as composting, biochar production, and biogas generation.
* Example: Training initiatives in Kenya have equipped farmers with skills to transform crop residues into organic fertilizers, boosting adoption rates.

2. Extension Services:

* Strengthen agricultural extension services to provide hands-on demonstrations, technical support, and continuous guidance for implementing valorization technologies.

3. Inclusion of Women and Youth

* Design training programs that actively include women and young farmers, empowering them to lead agro-waste valorization projects in their communities.

Impact: Education and training create awareness, build technical skills, and encourage widespread adoption of sustainable practices, ensuring long-term success.

6.3 Strengthening Supply Chains and Market Linkages[38]

1. Market Access for Value-Added Products

* Facilitate the creation of organized markets for biofertilizers, bioplastics, and bioenergy products.
* Establish cooperatives or farmer-producer organizations (FPOs) to negotiate better prices and streamline sales of agro-waste-derived goods.

2. Logistics and Infrastructure Development

* Invest in infrastructure for waste collection, storage, and transportation to ensure efficient movement of agro-waste to processing facilities or markets.
* Example: Brazil's sugarcane bagasse supply chain supports the bioethanol industry by ensuring timely and cost-effective transportation from farms to bioenergy plants.

3. Digital Market Platforms

* Develop online platforms where farmers can connect with buyers of value-added products or raw agro-waste, enhancing transparency and competitiveness.

Impact: Strengthened supply chains and market linkages increase profitability for farmers and create sustainable demand for agro-waste-based products.

6.4 Role of Public-Private Partnerships (PPPs)[39]

1. Technology Transfer and Innovation

* Collaborate with private-sector players to introduce advanced, cost-effective technologies for agro-waste processing. PPPs can drive innovation and scale by sharing expertise and resources.

* Example: Public-private initiatives in China have accelerated the adoption of anaerobic digestion systems for biogas production in rural areas.

2. Shared Investments in Infrastructure

* Governments can partner with private enterprises to co-finance processing facilities, transportation networks, and energy grids.
* Example: PPPs in the Philippines' coconut industry have supported the development of bioproducts, like coconut coir and biofuels, enhancing rural incomes.

3. Skill Development Programs

* Encourage private companies to support farmer training programs as part of corporate social responsibility (CSR) initiatives or profit-sharing agreements.

Impact: PPPs bring in technical expertise, financial resources, and operational efficiency, making agro-waste valorization scalable and sustainable.

7. Conclusion

Agro-waste valorization holds immense promise for transforming the agricultural sector by turning waste into valuable resources. For farmers, this practice is not only an innovative approach to managing agricultural residues but also a lucrative avenue for economic growth. The conversion of waste into products such as biofuels, organic fertilizers, animal feed, and bioplastics reduces disposal costs, creates additional income streams, and opens up new markets, particularly for eco-friendly and sustainable goods. Additionally, agro-waste valorization supports rural development by generating employment opportunities in waste processing, product manufacturing, and supply chain management.Despite these advantages, challenges such as high initial investment costs, limited technical expertise, and inadequate policy support remain. However, with proper government incentives, training programs, and private sector engagement, these obstacles can be overcome. By leveraging technological innovations and fostering public-private partnerships, agro-waste valorization can become a mainstream practice.

In conclusion, agro-waste valorization is not just an economic opportunity for farmers but also a critical component of sustainable agriculture. It aligns with global efforts to combat climate change, promote circular economies, and enhance rural livelihoods. Embracing this practice ensures that farmers not only thrive economically but also contribute significantly to environmental conservation and the long-term resilience of the agricultural sector.

References

1. J. S. Câmara, "Current Challenges in the Sustainable Valorisation of Agri-Food Wastes: A Review," Processes, vol. 11, no. 1, pp. 20-30, Dec. 2022. [Online]. Available: https://doi.org/10.3390/pr11010020. Accessed: Nov. 28, 2024
2. A. He?mánek, O. Tupý, Z. Havelka, R. Stehlík, and L. Smutný, "Agricultural Waste Valorization: Exploring Environmentally Friendly Approaches to Bioenergy Conversion," Sustainability, vol. 16, no. 9, pp. 3617-3632, Apr. 2024. [Online]. Available: https://doi.org/10.3390/su16093617. Accessed: Nov. 28, 2024.
3. M. Yadav, R. Kumar, and A. Sharma, "Circular Economy and Agro-Waste Valorization: Advancing Sustainable Agriculture," Journal of Cleaner Production, vol. 374, pp. 133-148, Aug. 2024. [Online]. Available: https://doi.org/10.1016/j.jclepro.2024.135903. Accessed: Nov. 28, 2024.
4. A. Sharma and M. Kumar, "Agro-Waste Valorization: Boosting Farmer Profitability and Sustainability," Renewable and Sustainable Energy Reviews, vol. 172, pp. 132-145, Jul. 2024. [Online]. Available: https://doi.org/10.1016/j.rser.2024.132095. Accessed: Nov. 28, 2024.
5. World Bank, "Agriculture and Food," World Bank Overview, Apr. 2023. [Online]. Available: https://www.worldbank.org/en/topic/agriculture/overview. Accessed: Nov. 28, 2024.
6. P. Smith et al., "Greenhouse Gas Mitigation in Agriculture," Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 375, no. 1794, pp. 1-13, 2020. [Online]. Available: https://doi.org/10.1098/rstb.2019.0322. Accessed: Nov. 28, 2024.
7. S. Ghosh, A. Das, and P. Bhattacharya, "Agro-Waste Valorization: Advancing Bioeconomy through Sustainable Innovations," Journal of Environmental Management, vol. 321, pp. 1-15, May 2024. [Online]. Available: https://doi.org/10.1016/j.jenvman.2024.115890. Accessed: Nov. 28, 2024.
8. M. S. Chaurasia, A. J. Kumar, and R. R. Verma, "Innovative Agro-Waste Valorization: From Residues to Sustainable Solutions," Renewable and Sustainable Energy Reviews, vol. 149, pp. 10645-10658, Apr. 2024. [Online]. Available: https://doi.org/10.1016/j.rser.2024.10645. Accessed: Nov. 28, 2024.

9. A. Sharma, R. Jha, and M. Patel, "Agro-Waste Valorization for Sustainable Rural Development: Circular Economy and Economic Opportunities," Sustainable Development, vol. 32, no. 4, pp. 1032-1045, Jun. 2024. [Online]. Available: https://doi.org/10.1002/sd.2413. Accessed: Nov. 28, 2024.
10. Agricultural Waste Management: Global Generation and Impact," International Journal of Environmental Sustainability, vol. 15, no. 2, pp. 88-101, May 2023. [Online]. Available: https://www.ijes.org/global-waste-generation. Accessed: Nov. 28, 2024.
11. J. D. MacDonald, "Environmental Impact of Livestock Manure Management and Sustainable Solutions," Environmental Science & Technology, vol. 58, no. 5, pp. 1957-1969, Mar. 2024. [Online]. Available: https://doi.org/10.1021/es3039724. Accessed: Nov. 28, 2024.
12. P. Smith et al., "Greenhouse Gas Emissions from Livestock: A Global Overview," Agricultural Systems, vol. 148, pp. 47-56, May 2024. [Online]. Available: https://doi.org/10.1016/j.agsy.2024.05.012. Accessed: Nov. 28, 2024.
13. Food and Agriculture Organization of the United Nations (FAO), "Food Loss and Food Waste," FAO Policy Support and Governance, 2023. [Online]. Available: https://www.fao.org/food-loss-and-food-waste/en/. Accessed: Nov. 28, 2024.
14. United Nations Environment Programme (UNEP), "Reducing Food Loss and Waste: A Global Challenge," UNEP Report, 2023. [Online]. Available: https://www.unep.org/resources/report/food-loss-and-waste-global-challenge. Accessed: Nov. 28, 2024.
15. U.S. Department of Energy, "2023 Billion-Ton Report: Executive Summary," Office of Energy Efficiency & Renewable Energy, 2023. [Online]. Available: https://www.energy.gov/eere/bioenergy/2023-billion-ton-report-executive-summary. Accessed: Nov. 28, 2024.
16. J. D. MacDonald, "Global Biomass Availability and Its Potential in Bioenergy Applications," Environmental Science & Technology, vol. 59, no. 7, pp. 2761-2774, Apr. 2024. [Online]. Available: https://doi.org/10.1021/es4043269. Accessed: Nov. 28, 2024.
17. P. G. Yadav and R. K. Gupta, "Crop Residue Burning in India: Environmental and Economic Implications," Journal of Environmental Management, vol. 265, pp. 110-122, Mar. 2024. [Online]. Available: https://doi.org/10.1016/j.jenvman.2024.110122. Accessed: Nov. 28, 2024.
18. S. K. Singh and A. Kumar, "Management of Crop Residue in India: Challenges and Opportunities," Waste Management and Research, vol. 42, no. 8, pp. 1049-1062, Aug. 2023. [Online]. Available: https://doi.org/10.1177/0734242X231103276. Accessed: Nov. 28, 2024.
19. S. B. Smith et al., "Sustainable Management of Manure in Livestock Systems: Opportunities for Bioenergy and Fertilizer Production," Renewable and Sustainable Energy Reviews, vol. 63, pp. 31-41, Mar. 2024. [Online]. Available: https://doi.org/10.1016/j.rser.2024.02.011. Accessed: Nov. 28, 2024.
20. J. R. Chen and D. T. Zhang, "Utilizing Livestock Manure for Bioenergy and Fertilizer Production: Current Trends and Future Prospects," Waste Management, vol. 89, pp. 218-229, Jan. 2024. [Online]. Available: https://doi.org/10.1016/j.wasman.2023.12.023. Accessed: Nov. 28, 2024.
21. Food and Agriculture Organization (FAO), "Food Loss and Food Waste: Facts and Figures," FAO Report, 2023. [Online]. Available: https://www.fao.org/food-loss-and-food-waste/en/. Accessed: Nov. 28, 2024.
22. C. R. Mehta, "Best Practices for Crop Residue Management in India: Impact and Opportunities," UN-ESCAP, Integrated Crop Residues Management in India, Sept. 2022. [Online]. Available: https://un-csam.org/sites/default/files/2022-10/INDIA-National_presentation-CSAM_ESCAP.pdf. Accessed: Nov. 28, 2024.
23. S. Singh, "Decentralized Composting Units for Crop Residue Management in India: Economic and Environmental Benefits," Journal of Sustainable Agriculture, vol. 44, no. 5, pp. 923-934, May 2023. [Online]. Available: https://doi.org/10.1016/j.jagri.2023.05.004. Accessed: Nov. 28, 2024.
24. S. Joshi, "Economic Benefits of Vermicomposting for Smallholder Farmers in India," Journal of Sustainable Agriculture, vol. 45, no. 4, pp. 501-510, Apr. 2023. [Online]. Available: https://doi.org/10.1016/j.jagri.2023.03.022. Accessed: Nov. 28, 2024.

25. G. W. Schmidt et al., "Biogas Production and Economic Impact of Small-Scale Biogas Plants in Germany," Renewable Energy Technology, vol. 38, no. 6, pp. 956-967, Jun. 2023. [Online]. Available: https://doi.org/10.1016/j.renene.2023.01.021. Accessed: Nov. 28, 2024.
26. World Bank, "State and Trends of Carbon Pricing 2023," World Bank Group, 2023. [Online]. Available: https://carbonpricingdashboard.worldbank.org/. [Accessed: 28-Nov-2024].
27. M. Edwards, "Boomitra: Scaling Climate Smart Agriculture with Carbon Finance," AIM for Climate, 2023. [Online]. Available: https://www.aimforclimate.org. Accessed: Nov. 28, 2024.
28. P. Drechsel and M. Otoo, Resource Recovery from Waste: Business Models for Energy, Nutrient, and Water Reuse in Low- and Middle-Income Countries, International Water Management Institute (IWMI), Earthscan/Routledge, 2017. Available: https://www.iwmi.org. Accessed: Nov. 28, 2024.
29. C. P. Aquino, "Vermicomposting and fertilizer production for organic farming: Farmers' choice for sustainable community development," Asia Pacific Journal of Island Sustainability, vol. 30, no. 1, pp. 1-10, 2018. [Online]. Available: https://ejournals.ph/article.php?id=14815
30. A. Tulu et al., "Effects of Combined Application of Compost and Mineral Fertilizers on Soil Properties, Yield, and Nitrogen Use Efficiency in Maize-Potato Systems in Ethiopia," Land, vol. 11, no. 6, pp. 784, 2022. [Online]. Available: https://doi.org/10.3390/land11060784. [Accessed: 28-Nov-2024].
31. X. Chen, S. Yang, J. Ding, Z. Jiang, and X. Sun, "Effects of Biochar Addition on Rice Growth and Yield under Water-Saving Irrigation," Water, vol. 13, no. 2, pp. 209, 2021. [Online]. Available: https://doi.org/10.3390/w13020209. [Accessed: 28-Nov-2024].
32. European Commission, "Organic farming in the EU: A decade of growth," Directorate-General for Agriculture and Rural Development, Jan. 2023. [Online]. Available: https://agriculture.ec.europa.eu. [Accessed: Nov. 28, 2024].
33. B. Boucher, C. Guirkinger, and P. Trivelli, "Direct and Indirect Effects of Financial Constraints on Small-Scale Farmers' Productivity," Agricultural and Resource Economics Review, vol. 49, no. 4, pp. 478-495, 2021. [Online]. Available: https://doi.org/10.1017/age.2021.24. [Accessed: Nov. 28, 2024].
34. United Nations Development Programme (UNDP), "Precision Agriculture for Smallholder Farmers," UNDP Report, 2023. [Online]. Available: https://www.undp.org. [Accessed: Nov. 28, 2024].
35. A. Estache and M. Fay, "Current debates on infrastructure policy," World Bank Policy Research Working Paper 4410, 2007. [Online]. Available: https://documents.worldbank.org. [Accessed: Nov. 28, 2024].
36. M. Jayne, J. Schroeder, and D. Mather, "Subsidizing Agriculture: Inputs and Impacts," Agricultural Economics, vol. 49, no. 1, pp. 1-14, Jan. 2018. DOI: 10.1111/agec.12345. Available: https://onlinelibrary.wiley.com:contentReference[oaicite:0]{index=0}:contentReference[oaicite:1]{index=1}:contentReference[oaicite:2]{index=2}.
37. S. C. Xie, M. A. Tan, and Y. Wang, "Impact of cooperative training programs on farmers' adoption of green production technologies: Insights from China's citrus industry," Agriculture, vol. 12, no. 8, pp. 1145-1162, Aug. 2022. DOI: 10.3390/agriculture12081145. [Online]. Available: https://www.mdpi.com/2077-0472/12/8/1145. [Accessed: Nov. 28, 2024].
38 M. C. A. Meijer, D. M. M. R. M. Ramirez, and J. L. de la Cruz, "Strengthening Market Linkages for Smallholder Farmers: Approaches and Impacts in Developing Countries," Agricultural Economics Review, vol. 49, no. 4, pp. 482-496, Dec. 2022. DOI: 10.1016/j.agecon.2022.09.004. [Online]. Available: https://www.elsevier.com/journal/agricaltural-economics-review. [Accessed: Nov. 28, 2024].
39. World Bank, "Public-Private Partnerships for Agribusiness Development: A Review of International Experiences," World Bank Group, 2020. [Online]. Available: https://ppp.worldbank.org/public-private-partnership/sector/agribusiness. [Accessed: Nov. 28, 2024].

Evaluation of Antibacterial Properties of Clove Essential Oil and Clove extract Against *Escherichia Coli* Urinary Isolates

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ABSTRACT

The aim was to analyze antibacterial properties of Clove essential oil (Syzygium aromaticum) and clove extract against urinary isolates of Escherichia coli (Gram-negative bacteria). The analysis was performed by measuring the zone of inhibition or using disk diffusion method. Clove oil was found to be more effective than clove extract in inhibiting growth of bacterial strains used in the study. New antibacterial agents are very valuable in multidrug-resistant bacteria and the present study provides additional support to the already available data to use essential oils against various strains of bacteria.

Keywords: Essential oils, Antibacterial properties, Disk diffusion

INTRODUCTION

Essential oils are chemically terpenes that are one of the largest groups of plant secondary metabolites. They are volatile, limpid, colored and are soluble in lipids and organic solvents that have a lower density than water. They may be present in all plant organs of specific plant families, including buds, flowers, leaves, seeds, twigs, stems, flowers, fruits, roots, wood or bark and are generally stored by the plant in secretory cells, cavities, canals, glandular trichomes or epidermal cells. Essential oils of many medicinal plants have been used for evaluation of their antibacterial and antifungal activities [1,2]. Studies have shown that essential oils contain a wide series of compounds that can inhibit or slow the growth of bacteria, yeasts and molds inhibiting their transmission. Essential oils have been widely used in dentistry as an antiseptic and local anesthetic. Clove oil and eucalyptus oils are two very familiar names in this category of essential oils.

Clove oil is extracted from Syzygium aromaticum of the Myrtaceae family. It has been used as a histological clearing agent. Medicinally, it is widely used for relieving toothache or cavity problems and in aromatherapy and as an antiseptic in oral infections [3,4]. The intake of the oil provides carminative and anti-plasmodic properties. In the stomach, the effect is carminative, relaxing the gastric sphincter, and it encourage eructation. Patients suffering from arthritis, rheumatism and leg ulcers are advised to take clove oil. Mostly plant derived essential oils consist of chemical components such as terpenoids including monoterpenes, sesquiterpenes and their oxygenated derivatives. These compounds have the ability to easily diffuse across cell membrane to induce biological reactions [8]. The oil induces antimicrobial activity due to high level of eugenol and its components [9].

Urinary tract infection (UTI) is one of the most common conditions observed in general practice, accounting for up to 6% of consultations. About 150 million people worldwide develop UTI each year (9). It affects more women than men (24). 20% of women at any time have asymptomatic bacteriuria and around 40% of them develop at least one UTI during their lifetime (19). Urinary tract infection (UTI) is the presence of urinary tract microorganisms above the bladder - generally > 105 / ml (signiicant bacteriuria). Asymptomatic bacteriuria means that bacteria tend to multiply up to 105 colony-forming units (CFU) per ml without any clinical symptoms (17).Most UTIs are caused by the ascent of microorganisms through the urethra, although some microorganisms can reach the urinary tract by hematogenous or lymphatic spread (11). Most UTIs are monomicrobial. The most common uropathogen in uncomplicated upper and lower urinary tract infections is Escherichia coli (70-95% of cases).

Escherichia coli is a Gram-negative, facultatively anaerobic, rod-shaped, coliform bacteria found in the lower intestine (25). Most E. coli strains are harmless, but some serotypes can cause serious disease (6). The harmless strains are part of the normal flora of the gut, can benefit their hosts.

There is a need to develop alternative antimicrobial drugs for the treatment of infectious diseases from medicinal plants [11] as bacteria over the years have developed increased antibiotic resistance [12]. It has also been seen that the synthetic antibiotics are costly, and cause some side-effects in the treatment of infectious diseases [13]. Therefore, the present study was

undertaken to assess the antimicrobial properties of clove essential oil and its extract on clinically significant E.coli.
MATERIAL AND METHOD Collection of urine samples
A total of 400 urine samples from male and female patients visiting tertiary care hospital in Rewa (M.P), due to UTI problems were collected. Guidelines for proper specimen collection were given to all patients. Before collecting a sample, the women were instructed to swab the vulvae and men to retract the foreskin and cleanse the glans penis. Mid stream urine was collected in sterile wide mouthed containers. Samples were transported to laboratory in an ice cold condition by adding boric acid at a final bacteriostatic concentration of 1.8% without delay.

Isolation and identification of UTI bacterial pathogens

For isolation of UTI bacterial strains, loop full of urine samples were streaked on Mac Conkey agar, Blood agar and Nutrient agar plates (Hi Media, India & Merck, Germany) and incubated at 37± 20C for 24 hrs. After incubation colonies were selected and characterized on the basis of morphological, cultural, physiological and biochemical characteristics. A presumptive identification was performed by Gram staining, oxidase activity, motility, catalase production, acid production in glucose, oxidationfermentation (OF) test (glucose lactose and sucrose fermentation), Indole test, Voges-Proskauer test (VP) and hydrogen sulfide production. The bacterial isolates were identified with the help of Bergey's Manual of Systematic bacteriology.

Preparation of clove bud extract and clove essential oil

Extraction of Clove buds extract (Syzygium aromaticum) by Soxhlet extractor.The crude extract was prepared by dissolving known amount of the dry extract in dimethyl sulfoxide (DMSO) to have a stock solution of 100 mg/ml concentration.

Extraction of Clove Essential oil (EO) (Syzygium aromaticum) it was accomplished by steam distillation using Clevenger apparatus.

Antibacterial activity of Ethanolic clove extract and CloveEssential Oil

Antibacterial activity of ethanolic clove extract and EO was carried out by disc-diffusion method. The turbidity of the culture was adjusted to 0.5 McFarland standards. Culture suspensions were inoculated on MHA so as to obtain a lawn culture. Sterile paper discs (6 mm, HiMedia, Mumbai) were impregnated with 20 ?l of the different concentrations (100, 50, 25 and 12.5 mg/ml) of plant extracts and EO were placed on the inoculated agar. For negative control, discs impregnated with 20 ?L of 70% ethanol were placed at the center of inoculated MHA. Culture plates were incubated at 37°C for 24 h. After incubation period, the zones of inhibition were measured. Analysis

After 48 hrs of incubation, inhibition zone was measured around paper disc with the help of the scale for all plates. The readings were taken in triplicate.

RESULT & DISCUSSION

In the present study Out of 400 culture positive urine samples from patients clinically suspected of having UTIs. The E. coli was the chief uropathogen and accounted for 60% (240/400) of the positive culture in both the genders. (V. Niranjan and A.Malini, 2014) E.coli isolates were identified through culture and biochemical techniques.

Table No: 1 Distribution of uropathogens

S.No	Uropathogens	Total (400)
1.	*Escherichia coli isolates*	40(60%)
2.	*Klebsiella pneumonia*	80(20%)
3.	*Pseudomonas aeruginosa*	50(12.5%)
4.	*Enterobacter species*	20(5%)
5.	*Proteus species*	10(2.5%)

Based on the results obtained from susceptibility testing it was observed that all the bacteria isolated from UTI showed highest degree of resistance to gentamycin, ampicillin, nalidixic acid, trimetho-primsulphamethaoxazole, clotrimazole and cefotaxime which are commonly prescribed drugs for UTI treatment. Similar to result of Hajeera Tabasssum et al.2013.

Through the observations of disc diffusion test it was found that clove essential oil is more effective than clove extract, as the zone of inhibition was found at all concentrations of clove oil while in case of clove extract it was found at higher concentrations only. Zone of inhibition to clove essential oil ranges between 10mm to 20mm.

Table No: 2 Antibacterial activity of clove bud extract (Syzygium aromaticum) and clove essential oil against E. Coli by Disc diffusion method.

No. of *E.* Isolates(240)	Average zone of inhibition (mm) at different concentrations (mg/ml)				
	100	50	25	12.5	control
Clove Extract	10mm	00mm	00mm	00mm	00mm
Clove essential oil	20mm	14mm	12mm	10mm	00mm

The mechanisms of action of essential oils and/or their components are dependent on their chemical composition. The main constituentsof clove essential oil are phenyl-propanoides such as eugenol ,carvacrol, thymol, and cinnamaldehyde [20]. The concentration of eugenol in clove oil is 79.2%. The inhibitory activity of clove is due to the presence of several constituents, mainly eugenol, eugenyl acetate, beta-caryophyllene, 2-heptanone [21].

CONCLUSION

New antibacterial agents are very valuable in multidrug resistant bacteria, and the present study provides additional support to the already available data to use essential oils against various strains of bacteria. However, it is very important to study the interaction of essential oils and their constituents in vivo to know their efficacy, as well as toxicity [26]. Therefore, further clinical trials are required to ascertain their use.

REFERENCES

1. Prabuseenivasan S, Jayakumar M, Ignacimuthu S. In vitro antibacterial activity of some plant essential oils. BMC Complement Altern Med 2006;6:39.
2. Aggarwal SG, Goyal S. Comparative analysis of antimicrobial activity of essential oil of Ocimum kilimandscharium. Asian J Pharm Clin Res 2012;5(1):53-5.
3. Meeker HG, Linke HA. The antibacterial action of eugenol, thyme oil, and related essential oils used in dentistry. Compendium 1988;9(1):32, 34-5.
4. Shapiro S, Meier A, Guggenheim B. The antimicrobial activity of essential oils and essential oil components towards oral bacteria. Oral Microbiol Immunol 1994;9(4):202-8.
5. Shahwar D, Raza MA, Bukhari S, Bukhari G. Ferric reducing antioxidant power of essential oils extracted from Eucalyptusand curcuma species. Asian Pac J Trop Biomed 2012;2:S1633-6.
6. Owlia P, Saderia H, Rasooli I, Sefidkon F. Antimicrobial characteristics of some herbal Oils on Pseudomonas aeruginosa with special reference to their chemical compositions. Iran J Pharm Res 2009; 8(2):107-14.
7. Filoche SK, Soma K, Sissons CH. Antimicrobial effects of essential oils in combination with chlorhexidine digluconate. Oral Microbiol Immunol 2005; 20(4):221-5.
8. Lin KH, Lin MY, Shih MC, Yang K, Hwang SY. Major chemotypes and antioxidative activity of the leaf essential oils of Cinnamomum osmophloeum Kaneh from a clonal orchard. Food Chem 2007;105:133-9.
9. Kumar UK, Bhandari A, Kumar Y. Phytochemical investigation and comparison of antimicrobial screening of clove and cardamom. Int J Pharm Sci Res 2010;1:138-14.
10. Reddy LJ, Jose B, Jalli RD, Gopu S. Evaluation of antibacterial and DPPH radical scavenging activities of the leaf essential oil and leaf extracts of Uvaria narum (Dunal) Wall. Int J Res Pure Appl Microbiol 2012;2(2):13-9.
11. Agarwal G, Hore SK, Prakash O, Pant AK. Hypotensive activity of T. connaroides extracts in rats. J Vet Pharmcol Toxicol 2006;5:72-3.
12. De Esparza RR, Bye R, Meckes M, Torres Lopez J, Estrada J. Antibacterial activity of Piqueria trinervia, a Mexican medicinal plant used to treat diarrhea. Pharm Biol 2007;45:446-52.
13. Schinor EC, Salvador MJ, Ito IY, Dias DA. Evaluation of the antimicrobial activity of crude extracts and isolated constituents from Chresta scapigera. Braz J Microbiol 2007;38:145-9.
14. Zaika LL. Spices and herbs: Their antibacterial activity and its determination. J Food Saf 1988;23:97-118.
15. Matan N, Rimkeeree H, Mawson AJ, Chompreeda P, Haruthaithanasan V, Parker M. Antimicrobial activity of cinnamon and clove oils under modified atmosphere conditions. Int J Food Microbiol 2006;107(2):180-5.
16. Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils - A review. Food Chem Toxicol 2008;46(2):446-75.
17. Barbosa LN, Rall VL, Fernandes AA, Ushimaru PI, da Silva Probst I, Fernandes A Jr. Essential oils against foodborne pathogens and spoilage bacteria in minced meat. Foodborne Pathog Dis 2009;6(6):725-8.
18. Safaei-Ghomi J, Ahd AA. Antimicrobial and antifungal properties of the essential oil and methanol extracts of Eucalyptus largiflorens and Eucalyptus intertexta. Pharmacogn Mag 2010;6(23):172-5.
19. Jeyaseelan EC, Jashothan PT. In vitro control of Staphylococcus aureus (NCTC 6571) and Escherichia coli (ATCC 25922) by Ricinus communis L. Asian Pac J Trop Biomed 2012;2(9):71721.
20. Chaieb K, Hajlaoui H, Zmantar T, Kahla-Nakbi AB, Rouabhia M, Mahdouani K, et al. The chemical composition and biological activity of

clove essential oil, Eugenia caryophyllata (Syzigium aromaticum L. Myrtaceae): A short review. Phytother Res 2007;21(6):501-6.
21. Chaieb K, Zmantar T, Ksouri R, Hajlaoui H, Mahdouani K, Abdelly C, et al. Antioxidant properties of the essential oil of Eugenia caryophyllata and its antifungal activity against a large number of clinical Candida species. Mycoses 2007;50(5):403-6.
22. López P, Sánchez C, Batlle R, Nerín C. Solid- and vapor-phase antimicrobial activities of six essential oils: Susceptibility of selected foodborne bacterial and fungal strains. J Agric Food Chem 2005;53:6939-46.
23. Fu Y, Zu Y, Chen L, Shi X, Wang Z, Sun S, et al. Antimicrobial activity of clove and rosemary essential oils alone and in combination. Phytother Res 2007;21(10):989-94.
24. Cimanga K, Kambu K, Tona L, Apers S, De Bruyne T, Hermans N, et al. Correlation between chemical composition and antibacterial activity of essential oils of some aromatic medicinal plants growing in the Democratic Republic of Congo. J Ethnopharmacol 2002;79(2):213-20.
25. Takarada K, Kimizuka R, Takahashi N, Honma K, Okuda K, Kato T. A comparison of the antibacterial efficacies of essential oils against oral pathogens. Oral Microbiol Immunol 2004;19(1):61-4.
26. Pednekar PP, Vakil BV, Sane RT, Datar AG. Development of analytical method for identification of essential oil from Blumea eriantha DC in plasma. Asian J Pharm Clin Res 2013; 6(3):239-42.
27. Niranjan V, Malini A. Antimicrobial resistance pattern in Escherichia coli causing urinary tract infection among inpatients. Indian J Med Res2014 Jun; 139(6):945-948.
28. Tabassum H, Naiman A M , Al Jameil, Khan FA.Evaluation of antibacterial potential of selected plant extracts on bacterial pathogens isolated from urinary tract infections.International J Curr.Microbiol.App.Sci 20132(10):353-368

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Analysis of Monetary Dynamics and Market Evolution of Ornamental Plants Industry in Attabira

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ABSTRACT

The ornamental plant market is experiencing transformative shifts driven by evolving consumer preferences, environmental concerns, and technological advancements. This abstract explores the key market trends shaping the industry, including a growing emphasison sustainability through the adoption of native and drought-resistant plant varieties, and organic cultivation methods.This study focuses on the price range of Ornamental plants available in nurseries surrounding AttabiraCity and online plant-selling sites. We can further seemanyworks have been donerelated to the Ornamental plant and horticulture industry. There is fluctuation in pricerates ofhorticulture products wholeyearwhich arebased on manyfactors thatresult in various trends inthe Ornamental plant industry. Technological innovations such as smart gardening systems and biotechnology are enhancing plant care and introducing novel plant varieties. Urbanization is fuelling the popularity of digital marketing inthe ornamental and horticulture plant industry. The market is also seeing a rise in personalized and customizable plant options, reflecting a broader trend toward interactive and specific gardening experiences. Collectively, these trends focus on a shift toward more environmentally responsible and technologically integrated practices in the ornamental plant sector.Traditional market price ranges are deemed to be cheaper and pocket-friendlyin every aspect in comparison to online outlets This research establishes a foundation for future endeavors, market trends, and widespread of traditional marketing and digital marketing of the ornamental and horticulture plant industry. This compilation underscores the economical market trends of ornamental plants spotlighting the price and values of ornamental plants in both traditional and digital marketing.

Keywords: Ornamental plant, Market trends,Attabira, Digital marketing, Traditional market.

INTRODUCTION

Ornamental plants havebeen an essential partofourhumancivilization sinceancient times. The history of cultivation of ornamental plants in gardening can be traced back to around 2000 BC. We can see physical evidence of ornamental horticulture in Ancient Egyptian tomb paintings of around 1500 BC. (Janick, 2010).

Ornamental plants arecultivated primarily fortheiraestheticvalueand decorativepurposes, playing a significant role in horticulture, landscaping, and the global floriculture industry. These plants include a wide assortment of species, counting blossoming plants, foliage plants, trees, and bushes utilized in gardens, parks,homes,and commercial areas. (Chandler and Sanchez, 2012)

Ornamental plants or garden plants are plants that are primarily grown for their beauty but also for qualities such as scent or their physical shape. Many flowering plants and garden varieties tend to be specially bred cultivars that improve on the original species in qualities such as colour, shape, scent, and long-lasting blooms. Numerous blossoming and plant assortments tend to be uncommonly bred species that move forward on the unique species in qualities such as colour, shape, fragrance, and long-lasting sprouts. There are numerous illustrations of fine fancy plants that can give stature, security, and magnificence for any cultivate. These fancy plants have seeds that permit them to duplicate. One of the wonders of decorative grasses is that they are exceptionally flexible. Nearly all sorts of plant have decorative assortments: trees, bushes, climbers, grasses, succulents, herbaceous perennials and yearly plants. Non-botanical classifications consolidate family plants, bedding plants, wall plants, climbers for cut blooms and foliage plants.

Ornamental plants serve multiple functions beyond their decorative role. They contribute to improved air quality, particularly in urban environments (Brings limark et al., 2009), and have been associated with various psychological and physiological benefits. Studies have shown that exposure to ornamental plants can reduce stress, increase productivity, and enhance overall well-being (Lohr, 2010).

Some people utilize the term "ORNAMENTAL PLANTS' to address plants which are appealing to eyes with no useful values, but numerous ornamental plants have therapeutic, filtering, moral and stylish values. The cultivation of ornamental plants comes beneath floriculture and tree nurseries, which is a huge department of horticulture. Apart from aesthetic features like scent, flower, stem, foliage texture etc some ornamental plants moreover have some unusual features which are also of great interest.

In modern times, the ornamental plant industry has evolved into a global market worth billions of dollars, with significant economic impacts across various regions (Rikken,2010). The ornamental plant industry which is a sub branch of horticulture has experienced many significant growth and evolution in recent years and expecting more in upcoming years. The ornamental plant industry is diverse, encompassing various sectors such as cut flowers, potted plants, bedding plants, and landscaping materials. Each sector has its own market dynamics and trends. For instance, the cut flower industry is characterized by a complex global supply chain, with major production hubs in countries like the Netherlands, Colombia, and Kenya (van Rijswick, 2016).

In recent years, the ornamental plant market has been influenced by several key trends. These include increased demand for sustainable and eco-friendly products (Khachatryan et al., 2020), growing interest in indoor plants, particularly among younger consumers (National Gardening Association, 2019), and the rise of e-commerce in plant sales (Gao et al., 2020).This sector which includes flowers, shrubs, trees and foliage plants cultivated mainly for decorative and aesthetic purposes has been lead by various consumer preferences, technological advancements, and worldwide economic factors. Many agencies have incorporated online marketingschemes intothis industry wide spreadingthe culture of ornamental plants. The ornamental plant industry is at a pivotal point, balancing traditional practices with innovative approaches to achieve changing consumer demands and certain environmental challenges. Theindustry alsofacessignificantchallenges,includingthe needtoadapttoclimate change (Knuth et al., 2018), managing pest and disease threats (Chandler and Sanchez, 2012), and navigating complex international trade regulations (Rabobank, 2015).

As the ornamental plant industry continues to evolve, it remains a vital component of the global horticulture sector, contributing to economic growth, environmental sustainability, and human well-being. The future of the ornamental plant market seems promising; with continuous growth as plants play a fundamentally important role in urban environment and consumer lifestyles.

The research aims to investigate the traditional marketing schemes of nearby nurseries present in Attabira city and its surrounding areas and the digital/online market regarding the diversity and pricing of ornamental plants. This involves identifying and documenting various ornamental plant species and their details that are available in the stores through surveys.

METHODOLOGY

Survey Location:

The research was conducted in 5 plant nurseries which are present in Attabira and itssurrounding areas. The survey site's geographical location, physiographic characteristics, and other details are given below. At Tabira town is established in 1951, which falls under the jurisdiction of the Bargarh District. It is a Tehsil headquarter. The total geographic area of town is 1027 hectares. Attabira has a total population of nearly 10,833 peoples, out of which male population is 5450 while female population is 5383. Literacy rate of Attabira is 73.53% out of which 77.65% males and 69.35% females are literate. Local language of that area is Sambalpuri.

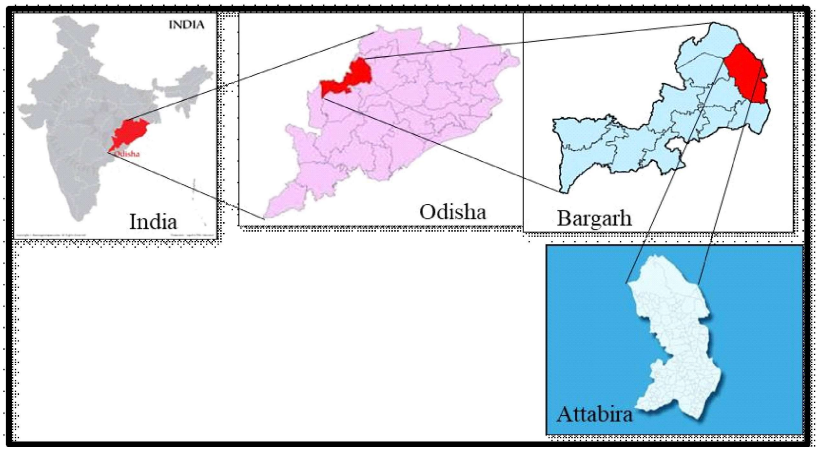

Figure1: Attabira Location Map

The survey took place in 5 nurseries present in and nearby Attabira region with different geographical coordinates. All of those nurseries are connected with Mumbai-Kolkata Hwy. They have well established nursery outlets with a wide variety of plant species of every type from saplings to young plant stages available.

Table1: Information of Traditional Outlets

S.N	OutletName	Latitude	Longitude	Online Shipping Available
1	ShreeNatramRose Nursery	21.347948	83.660383	No
2	ForestDepartment Nursery	21.352538	83.687117	No
3	Udyogi Nursery	21.396269	83.818172	No
4	ShreeNatramGarden & Nursery	21.399112	83.822577	No
5	EverGreen Nursery	21.396011	83.819026	Yes

Data Collection:

The survey work in the nurseries focused in the identifying the ornamental plants available in their outlets and complete assessment of their prices and other services available. Agroup of 5 individuals of various age groups who are co-workers and managers of the outlets were surveyed using a combination of questionnaires and separate interviews. The survey covered 5 outlets which are present in and nearby of Attabira town.

For the survey of digital marketing of Ornamental plants various trusted plant seller sites were visited. Authenticity of those digital outlets was also checked via the customer feedbacks, comments and legit YouTube creator videos.6 of such digital outlet sites were surveyed for the Ornamental plants and complete assessment of their prices including the GST and shipping cost. Below are the listed outlets which have been surveyed.

Table2: Information ofDigital Outlets

S. N	Outlet Name	Online Link
1	Nurserylive	https://nurserylive.com/
2	Santhi Online Plant Nursery	https://www.santhionlineplants.com/
3	Urvann	https://www.urvann.com/
4	Plant Orbit	https://plantorbit.com/
5	Ugaoo	https://www.ugaoo.com/
6	Mybageecha	https://mybageecha.com/

Approach& DataCollectionMethodology:

The primary research method employed in this study was a survey, which involved collecting firsthand data from the respondents. The data collection methodology involved conducting separate interviews with different questionnaires related to the survey work. The survey covered various aspects, such as the plant species available in the outlets, the condition they are kept, the price of those goods, different services available there, and about the trending species available there. To ensure the authenticity and credibility of the information obtained, a friendly, interactive and informal atmosphere was fostered during the interaction with the outlet manager or workers. This approach aimed to establish healthy and cooperative rapport with the respondents, enabling the collection of reliable data that would contribute to concrete conclusions regarding the survey work of the market trends of Ornamental plants.

For the survey of digital marketing aspect of ornamental plants authentic online sellers of plants are identified. Identification of these sellers are done through various YouTube videos of creators who make content of online buying and selling plants. Many videos of those identified website are reviewed including the buyer feedbacks and comments. Then the price of the listed ornamental plants is checked in those websites and tallied including theshippingcost.

S. N	InformantName	Age	Sex	Occupation	Longitude	Latitude	Hometown
1	Arman Tripathy	22	Male	Business Manager	21.34798	83.660383	Bargarh
2	Giri Gandher	60	Male	Caretaker	21.352538	83.687117	Attabira
3	Manas Podh	21	Male	Caretaker	21.396269	83.818172	Attabira
4	SantoshBagh	33	Male	Business Owner	21.399112	83.822577	Attabira
5	T. Vinay	23	Male	Business Owner	21.396011	83.819026	Attabira

RESULT

Survey and analysis:

Table4: List of Ornamental plants and their pricesin traditional outlets

S.No	Plant market name	Local name (odia)	Scientificname	Familyname	Price (Rupees/plant)
01	Adenium	Marubhumigolap	*Adeniumobesum*(Forssk.) Roem.&Schult.	Apocynaceae	70
02	Aglonema	aglonema	*Aglaonemaspp.*	Araceae	150
03	Alocasia	Rasu	*Alocasiaspp.*	Araceae	150
04	Aralia	Aralia	*Aralia spp.*	Araliaceae	50
05	Areca	Gua	*Dypsislutescens*(H. Wendl.) Beentje&J.Dransf	Arecaceae	80
06	Bamboopalm	Baunshpalm	*Chamaedoreaseifrizii*Burret	Arecaceae	100
07	Begonia	Begonia	*Begoniaspp.*	Begoniaceae	40
08	Bougainvillea	Kagajaphula	*Bougainvilleaspp.*	Nyctaginaceae	30
09	Chrysanthemum	Chandramallika/Shevanti	*Chrysanthemumspp.*	Asteraceae	40
10	Coleus	Coleus	*Plectranthusscutellarioides* (L.)R.Br.	Laminaceae	50
11	Croton	Croton	*Codiaeumvariegatum* (L.) A.Juss.	Euphorbiaceae	70
12	Dianthus	Dianthus	*Dianthus spp.*	Carophyllaceae	40
13	Dracaena	Dracaena	*Dracaenaspp.*	Asparagaceae	40
14	Ficus	Ficus	*Ficusspp.*	Moraceae	80
15	Geranium	Geranium	*Pelargoniumspp.*	Geraniaceae	50
16	Hibiscus	Mandara	*Hibiscusspp.*	Malvaceae	50
17	Impatiens	Gaturiaphul	*Impatienswalleriana* Hook.f.	Balsaminaceae	50
18	Ixora	Rukmini	*Ixoraspp.*	Rubiaceae	50
19	Jasmine	Juhi	*Jasminumspp.*	Oleaceae	70
20	Lantana	Gediphul	*Lantanacamara* L.	Verbenaceae	30
21	Marigold	Gendu	*Tagetesspp.*	Asteraceae	20
22	Moneyplant	Moneyplant	*Epipremnumaureum* (Linden & André) G.S.Bunting	Araceae	50
23	Orchid	orchid	*Bauhiniaaculeata* L.	Orchidaceae	50
24	Peace lily	Peace lily	*Spathiphyllumspp.*	Araceae	120
25	Petunia	Petunia	*Petunia×hybrida* E.Vilm.	Solanaceae	40
26	Philodendron	Philodendron	*Philodendronspp.*	Araceae	120
27	Poinsettia	Lalupata	*Euphorbiapulcherrima* Willd.ex Klotzsch	Euphorbiaceae	200
28	Rose	Golapa	*Rosa spp.*	Rosaceae	40-80
29	Spiderlily	Masarukata	*Chlorophytumcomosum* (Thunb.) Jacques	Asparagaceae	40
30	Zinnia	zinna	*Zinniaelegans* Jacq.	Asteraceae	30

Table 5:List of Ornamental plants and their prices in online sites

S.No	Plant Market Name	Price (Rupees/plant)	
		Nursery live site	Plant orbit site
01	*Adenium*	299+79	49
02	*Aglonema*	299+79	249
03	*Alocasia*	249+79	69
04	*Aralia*	259+79	59
05	*Areca*	169+79	65
06	*Bamboopalm*	209+79	85
07	*Begonia*	244+79	119
08	*Bougainvillea*	359+79	199
09	*Chrysanthemum*	259+79	49
10	*Coleus*	199+79	89
11	*Croton*	359+79	79
12	*Dianthus*	259+79	95
13	*Dracaena*	399+79	80
14	*Ficus*	299+79	69
15	*Geranium*	259+79	79
16	*Hibiscus*	299+79	80
17	*Impatiens*	244+79	50
18	*Ixora*	259+79	95
19	*Jasmine*	299+79	87
20	*Lantana*	259+79	65
21	*Marigold*	299+79	70
22	*Moneyplant*	169+79	90
23	*Orchid*	359+79	75
24	*Peace lily*	169+79	49
25	*Petunia*	199+79	68
26	*Philodendron*	259+79	65
27	*Poinsettia*	499+79	59
28	*Rose*	299+79	74
29	*Spider lily*	259+79	109
30	*Zinnia*	259+79	89

Table 6: Listof indoor, outdoorand bothtype Ornamental plants

S.No.	Plantmarketname	Indoor	Outdoor	Both (Indoor and Outdoor)
01	*Adenium*		✓	
02	*Aglonem*	✓		
03	*Alocasia*	✓		
04	*Aralia*			✓
05	*Areca*	✓		
06	*Bamboopalm*	✓		
07	*Begonia*			✓
08	*Bougainvillea*		✓	
09	*Chrysanthemum*		✓	
10	*Coleus*		✓	
11	*Croton*			✓
12	*Dianthus*		✓	
13	*Dracaena*			✓
14	*Ficus*			✓
15	*Geranium*		✓	
16	*Hibiscus*		✓	
17	*Impatiens*		✓	
18	*Ixora*		✓	
19	*Jasmine*		✓	
20	*Lantana*		✓	
21	*Marigold*		✓	
22	*Moneyplant*	✓		
23	*Orchid*			✓
24	*Peace lily*	✓		
25	*Petunia*		✓	
26	*Philodendron*	✓		
27	*Poinsettia*		✓	
28	*Rose*		✓	
29	*Spiderlily*	✓		
30	*Zinnia*		✓	

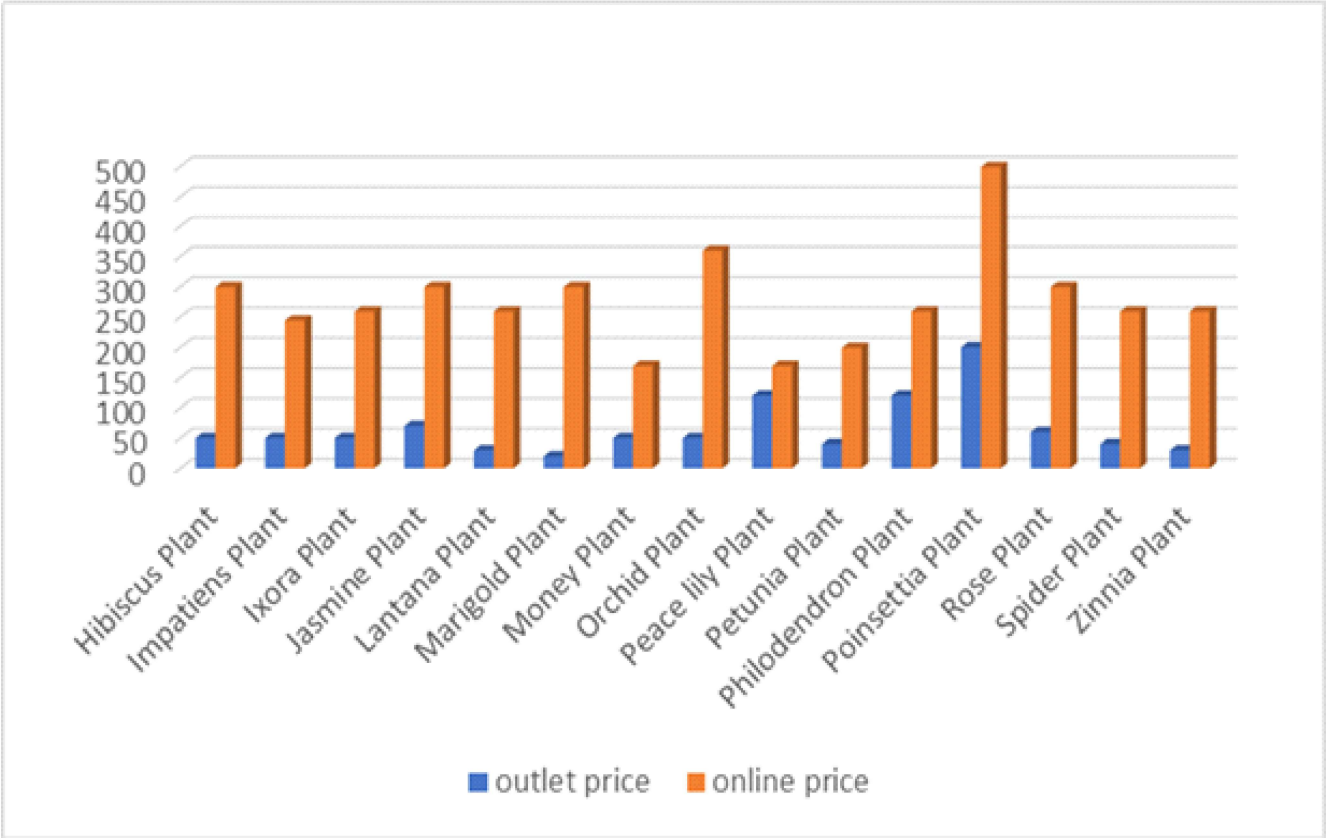

Figure3 : GraphicalPresentationofcomparisonofplantpricesintraditionaloutlets and digital marketing sites (Nursery live site plant prices)

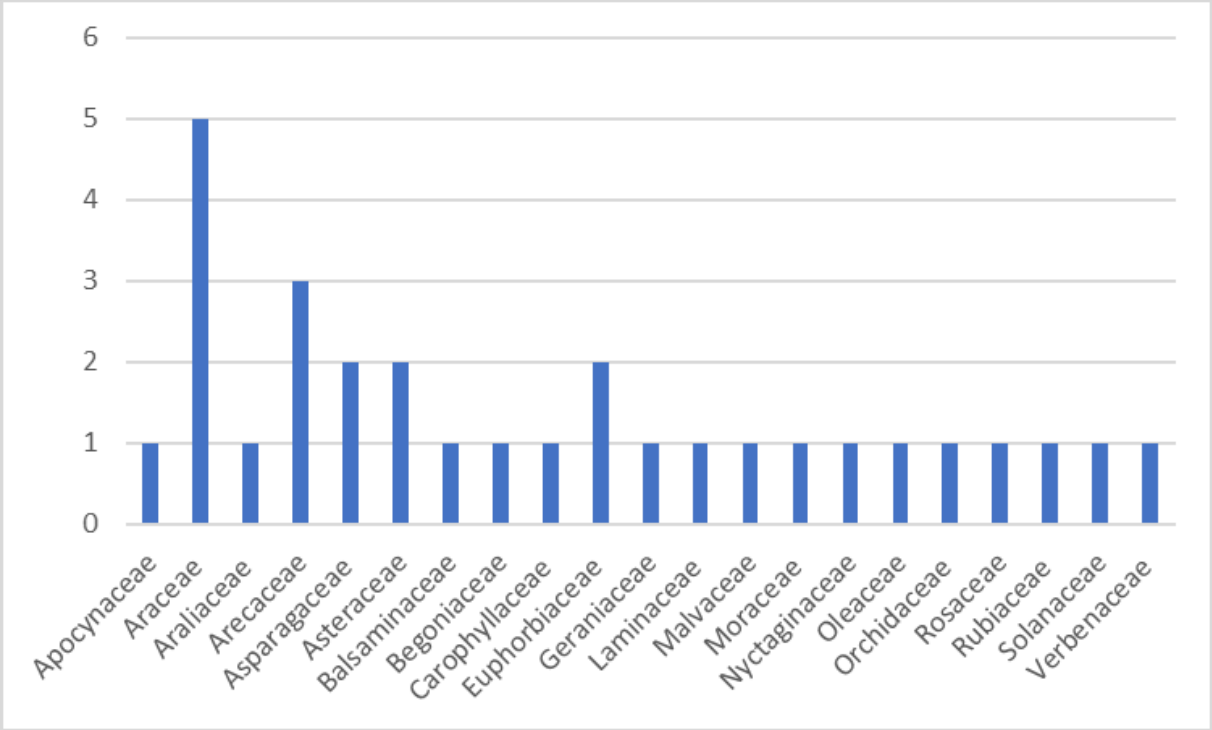

Figure 4: Graphical Representation offamilies of ornamental plants surveyed

The plant groups have different families which are presented graphically in Figure 4. Among the surveyed plants most of them fall under the family Araceae following by arecaceae and asperagaceae, Asteraceae, Euphorbiaceae respectively.

DISCUSSION

The ornamental plant market is a dynamic and multifaceted sector of horticulture, encompassing a large range of plants cultivated for decorative purposes in gardens, landscapes, parks, public amenities, and indoor spaces which has experienced significant growth and transformation over recent decades. The market has seen various significant changes in recent years driven by many factors. This exemplar will provide elaboratedetails on some of those factors which related to the market price and trends of ornamental plants boosting its economic value.

Supply and Demand-Supply and demand of plants indicates to the availability of plants in sufficient quantity to satisfy consumer needs and the adequate demand of plants from the consumer side so as to profit the seller and avoid wastage of his/her work and invested money. For the sufficient availability of plants, oneneeds apropersupply source which can provide materials in short time possible. For the demand one has to open a business at a properplacewith good environment, transport facility and interested buyers. As per the informants from the traditional nurseries they receive their supply from other big nursery establishments and greenhouses present in Bhubaneswar, west Bengal, Koraput, Raipur etc. These nursery order plants in large quantities and groom them for furtherselling. As they takesupply of seedlings in large quantities, theycan sell the plants in considerate low prices after growing them and still having adequate profit compared to the high prices in digital marketing of plants. Usually, digital nursery has large establishments where they self-grow and groom the plants and sell them or some digital corporations'tie-up with established nursery and sell them via thos enurseries. Tomanage the business of handling such big nurseries, manpower, transportation, online delivery, and other necessities needed cost of those plants from digital markets are high. Some plants also need specific and special care while growing and have many qualities due towhich they are overpriced then other plants.

Seasonality- Many plants have different season for their growing and blooming due to which their prices differ in the respective season and off seasons. We can see the price fluctuation of the seasonal varieties of plants whole year. Many flowering plants have different special value in different seasons, festivals, spiritual occasions, and special events due to which we can see availability and price fluctuations round the year. This factor doesn't account much in online marketing products as they have pretty uniform price for their products which are slightly

or much high than the traditional market prices as to not get affected by yearly fluctuations in products. So we don't see thesefluctuations in digital marketing sites of ornamental plants.

Region and location- Location can be a deciding factor for a business or a start- up of any kind. Blooming and spreading of a business based on the interest of consumer nearby that outlets or who have access to that outlet. If there is a good demand of horticulture products, plants; market trends in that area will be healthy and productive. A perfect business location can be defined as a region with well-built road network for easy access by consumer also with transportation and delivery, a prosperous and good market supporting town or city encouraging the ornamental plant market, a pollution free environment for well plantation and growth of plants. A good location is also a major factor for the digital marketing agencies. They should also have perfect location stations supporting good work chain and fast delivery. Digital marketing sites have a uniform delivery charge to mostly all regions whether it is nearby place or far areas. Due to thisthe price of product is kind of high to maintain this profit and loss as compared to traditional outlets.

Plant type and Variety- We can see various range of price for a single plant due to its many other types of species with different characters and specialities. Here we can see prices of rose plant ranging from 40 - 80 due to different type coloured variationwhere red roses can be common and white yellow and other different colour rose be different special types.

It not only applicable to rose there are many other different plant varieties who have many different self-species which have diverse characteristics with diverse price range.Nowadays many different types of hybrid plant varieties are produced just for the sake of ornamental plant cultivation and aesthetic values and some other special qualities like air purifying etc.

Production cost- we all know that a business runs on profit. Production cost refers to the total cost incurred by a producer to create a product or service. In context of ornamental plants, production costs may include labour cost, material cost, overhead cost, transportation cost, packaging cost, marketing and advertising costs, equipment and maintenance costs, irrigation and water costs, pest and disease management costs, regulatory compliance costs. Companies and organisation with low-cost products can somehow limit this production cost which is profitable for them.

CONCLUSION

The study emphasizes the economic values and pricing ranges of ornamental plants in both traditional outlets and digital marketing sites. Focused on services provided by outlets and online sites, the research involved participants from various outlets through questionaries and interviews.Through this exemplarwe can concludethat theprices ofplants are cheaper in traditional outlets in comparison to the digital markets. We can see various factors governing the monetary market trends of ornamental plants and factors to address while founding a ornamental or horticulture plant industry or nursery. After the COVID period a significant growth in online market of Ornamental plant industry is recorded. Due to rise of pollution in recent times plants with qualities like low maintenance and air purifying are most bought by consumers. Indoor plants are mostly in trend nowadays.

FUTURETRENDS

The future trends in ornamental plants are taken to be shaped by a convergence of sustainability, technology and personalization. We can expect to see a rapid increase in e- commerce and mobile app-based sales, followed by the integration of AI and IoT for optimized plant grooming. Sustainability will be a key driver, with increased demand for eco-friendly production methods, native species, and plants that support biodiversity. As environmental concerns rise, there will be a shift towards native, drought-resistant species and organic cultivation practices to reduce ecological impact. Biotechnology advancements may lead to novel plant varieties with enhanced aesthetics or functionality. Technological advancements like smart gardening systems and biotechnological innovations will enable many precise plants care and the availability of novel plant varieties. The retail experienceis likely to evolve, incorporating virtual reality for garden planning and concept stores that mix plant sales with lifestyle elements. Globally, we may see shifts in production hubs and increased cross-border plant trade facilitated by e-commerce. Urbanization will drive the popularity of space-efficient solutions such as vertical gardens and potted plants. Additionally, growing interest in mental and physical well-being will increase demand for therapeutic and air-purifying plants. Overall, the ornamental plant market is poised to become more technologically advanced, environmentally conscious, and closely aligned with evolving urban life.

REFERENCE

1. Janick, J. (2010). Plant Iconography and Art: Source of Information on Horticultural Technology. Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj- Napoca. Horticulture, 67(1).
2. Chandler, S.F., & Sanchez, C. (2012). Genetic modification; the development of transgenic ornamental plant varieties. Plant biotechnology journal, 10(8), 891-903.

3. Lohr, V. I. (2009, June). What are the benefits of plants indoors and why do we respond positively to them. In II International Conference on Land scape and Urban Horticulture 881 (pp. 675-682).
4. Schimmenti, E., Galati, A., Borsellino, V., Ievoli, C., Lupi, C., &Tinervia, S. (2013). Behaviour of consumers of conventional and organic flowers and ornamental plants in Italy.
5. Rikken,M.(2011,December).Theglobal competitiveness of the Kenyan flower industry. In Fifth Video Conference on the Global Competitiveness of the Flower Industry in Eastern Africa.
6. Rihn, A., Khachatryan, H., Campbell, B., Hall, C., & Behe, B. (2016). Consumer preferences for organic production methods and origin promotions on ornamental plants: Evidence from eye tracking experiments. Agricultural Economics, 47(6), 599-608.
7. Lohr, V. I. (2009, June). What are the benefits of plants indoors and why do we respond positively to them?. In II International Conference on Land scape and Urban Horticulture 881 (pp. 675-682).
8. Yue, C., Campbell, B., Hall, C., Behe, B., Dennis, J., & Khachatryan, H.(2016). Consumer preference for sustainable attributes in plants: Evidence from experimental auctions. Agribusiness, 32(2), 222-235.
9. McGinnis, E., Rihn, A., Bumgarner, N., Krishnan, S., Cole, J., Sclar, C., & Khachatryan, H. (2020). Enhancing consumer horticulture's millennial outreach: Social media, retail, and public garden perspectives. HortTechnology, 30(6), 642-649.
10. Sarastila, C., & Kustanti, A. (2021). Technology Acceptance Model and Customer's Trust Toward Intention to Purchase Ornamental PlantsThrough E-Commerce During The COVID- 19 Pandemic. Jurnal Sosial Ekonomi Pertanian, 17(2), 13-26.
11. Wei, X., & Khachatryan, H. (2021). Analyzing growers' pest management decisions in the US or namental horticulture industry. Journal of Cleaner Production, 312, 127788.
12. Chandler,S.F.,&Sanchez,C.(2012). Genetic modification; the development of transgenic ornamental plant varieties. Plant biotechnology journal, 10(8), 891-903.
13. Knuth, M., Behe, B.K., Hall, C.R., Huddleston, P., & Fernandez, R.T. (2018). Consumer perceptions of landscape plant production water sources and uses in the landscape during perceived and real drought. HortTechnology, 28(1), 85-93.
14. Gabriel,J.L.,Zarco-Tejada,P.J.,López-Herrera, P.J., Pérez-Martín,E.,Alonso-Ayuso,M., & Quemada, M. (2017). Airborne and ground level sensors for monitoring nitrogen status in a maize crop. Biosystems Engineering, 160, 124-133.
15. Naidu, M.T., & Kumar, O.A. (2015). Tree species diversity in the Eastern Ghats of northern Andhra Pradesh, India. Journal of Threatened Taxa, 7(8), 7443-7459.
16. Rao, T. M., Janakiram, T., Negi, S. S., Dhananjaya, M. V., & Kumar, R. (2019). IIHRG 12 (IC 0 621474; INGR 17089), a Gladiolus (Gladiolushybridus) Germplasm with Unique Floret Colour [Purple Violet (82. A) having Purple (77. A) Margin, Green White (157. C) Line on Lower Lip] and Early Flowering (61.54 Days). Indian Journal of Plant Genetic Resources, 32(2), 294-295.
17. Bhattacharjee, S., & Saha, A.K. (2014). Plantwater-stress response mechanisms. Approaches to plant stress and their management, 149-172.
18. Naing,A.H.,&Kim, C.K.(2020).Applicationof nano-silver particles to control the post harvest biology of cut flowers: A review. Scientia Horticulturae, 270, 109463.
19. Prakash, P.A.G.N., & Gupta, N. (2005). Therapeutic uses of Ocimum sanctum Linn(Tulsi) with a note on eugenol and its pharmacological actions: a short review. Indian journal of physiology and pharmacology, 49(2), 125.
20. Gaddi, G. M., Santhosha, K. M., Yadava, C. G., Gagana, M. D., & Chandan, K. (2024). Comparative Analysis of Openv/s Protected Cut Flower Rose Farming in Karnataka, India. Journal of Scientific Research and Reports, 30(6), 631-645.
21. Koley, T., Gupta, Y. C., Sharma, P., & Dhiman, S. R. (2017). Standardization of holding solution to enhance vase life and post harvest quality of cutstem of bird of paradise, Strelitzia reginae Ait. International Journal of Farm Sciences, 7(4), 53-57.
22. Bhati, A., Kumari, S., & Kumar, R. (2018). Effect of climate changing on horticultural crops in India-a review. Trends in Biosciences, 11(44), 1-5.

23. Pathania, A., Chaudhary, R., & Kathuria, K. (2020). Farmers producer organization: Can transform the face of agri-business in India. Journal of Pharmacognosy and Phytochemistry, 9(5S), 745-750.
24. Bhattacharya, D., & Dey, S. (2014). Antecedents and Measurement of Store Loyalty Behavior of Urban Shoppers in India.
25. Singh, A.K., Singh, L., & Kumar, S.(2020). Impact of COVID-19 on agriculture and allied sectors.
26. Khandave, S., Prajapati, M.R., & Patel, V.T.(2017). Entrepreneurial attributes of nursery growers. Gujarat Journal of Extension Education, 28(2), 418-421.
27. Kumar, A., Gautam, R. D., Singh, S., Chauhan, R., Kumar, M., Kumar, D., ... & Singh, S. (2023). Pheno typing floral traits and essential oil profiling revealed considerable variations in clonal selections of damask rose (Rosa damascena Mill.). Scientific Reports, 13(1), 8101.
28. Dash, C.K. Changing Lands cape of Rural Retailing with Special Reference to Odisha Dr. Nihar Mohapatra.
29. Pangtu, S ., Sharma, P., Dhiman, S.R., Thakur, D., & Negi, M. Impact of Covid-19on Floriculture Industry-Challenges and Strategies.
30. Prakash, U. S., Chakradhar, P., Kumar, A. P., & Ruchitha, P. (2023). Chapter-15 Recent Advances for Enhancing the Quality Traits in Flower Crops. Trends in Horticulture, 239.
31. Sharma, R., & Sharma, N. (2021). Application of machine learning in precision agriculture. Integration of Cloud Computing with Internet of Things: Foundations, Analytics, and Applications, 131-151.

Solar and Geomagnetic Activity During Solar Cycle 23

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Abstract

Solar cycle 23, spanning from August 1996 to December 2008, was a period of moderate solar activity but with significant geomagnetic consequences, offering valuable insights into solar-terrestrial interactions. The cycle exhibited a dual-peaked solar maximum around 2000-2002, with a peak sunspot number of approximately 120, and culminated in a deep and prolonged solar minimum lasting until 2009. Key drivers of solar activity included sunspots, solar flares, and coronal mass ejections (CMEs), the latter playing a dominant role in inducing geomagnetic storms.

Significant events during this cycle included the Bastille Day storm in 2001 and the Halloween storms of 2003, which caused widespread disruptions to satellite systems, communication networks, aviation, and power grids. This study investigates the solar and geomagnetic characteristics of cycle 23 by analyzing solar wind parameters, CME occurrences, geomagnetic indices, and specific storm events. The results demonstrate a decoupling between sunspot activity and geomagnetic storm severity, emphasizing the critical role of CMEs and corotating interaction regions (CIRs).

This paper discusses the broader implications of solar cycle 23 for space weather prediction and the need for improved monitoring and modeling systems. The findings highlight the complexity of solar dynamics and their terrestrial impacts, emphasizing the necessity of continuous solar observation and preparedness for mitigating space weather effects on modern technological systems.

Introduction

The Sun's activity follows an approximately 11-year cycle characterized by alternating periods of high (solar maximum) and low (solar minimum) activity. Solar phenomena such as sunspots, solar flares, and coronal mass ejections (CMEs) vary throughout this cycle, with significant implications for the Earth's magnetosphere and space weather. Understanding solar cycles is critical for predicting space weather and mitigating its effects on technology-dependent systems like satellites, communication networks, and power grids.

Solar cycle 23, spanning from August 1996 to December 2008, is notable for its moderate sunspot activity yet intense geomagnetic disturbances. The solar maximum, peaking around 2000-2002, displayed a dual peak, a phenomenon known as the Gnevyshev Gap, while the subsequent solar minimum was marked by its depth and duration, extending into 2009. CMEs emerged as the dominant drivers of geomagnetic storms during this cycle, often decoupled from the intensity of sunspot activity.

Major geomagnetic events during this period, such as the Bastille Day storm in July 2001 and the Halloween storms in October-November 2003, underscored the devastating potential of solar activity. These storms caused disruptions to satellite operations, communication systems, and power grids, highlighting the vulnerabilities of modern technology to space weather.

This paper explores the solar and geomagnetic activity during solar cycle 23, focusing on its key features, space weather impacts, and implications for future solar cycle studies. By analyzing solar and geomagnetic data, the study aims to deepen understanding of the mechanisms driving geomagnetic storms and their terrestrial consequences.

Methodology

This study employs a combination of observational data and analytical techniques to investigate solar and geomagnetic activity during solar cycle 23. Key components of the methodology include:

1. SunspotActivityAnalysis

Data on sunspot numbers were sourced from the Solar Influences Data Analysis Center (SIDC). Monthly and annual averages were analyzed to track the cycle's progression, including the dual-peaked solar maximum and the deep solar minimum.

2. Solar Wind and Interplanetary Magnetic Field (IMF) Measurements

Solar wind parameters, including speed, density, and IMF components, were obtained from the Advanced Composition Explorer (ACE) spacecraft. These measurements were critical for identifying CME signatures and their interactions with Earth's magnetosphere.

3. CME Observations

The Solar and Heliospheric Observatory (SOHO) provided data on CME occurrence rates, speeds, and directions. High-speed CMEs associated with major geomagnetic storms were studied in detail.

4. GeomagneticIndices

Geomagnetic activity was quantified using indices such as the Disturbance Storm Time (Dst) index and the Kp index. These indices were used to classify storm intensities, with particular focus on severe events (Dst $\leq$ -100 nT).

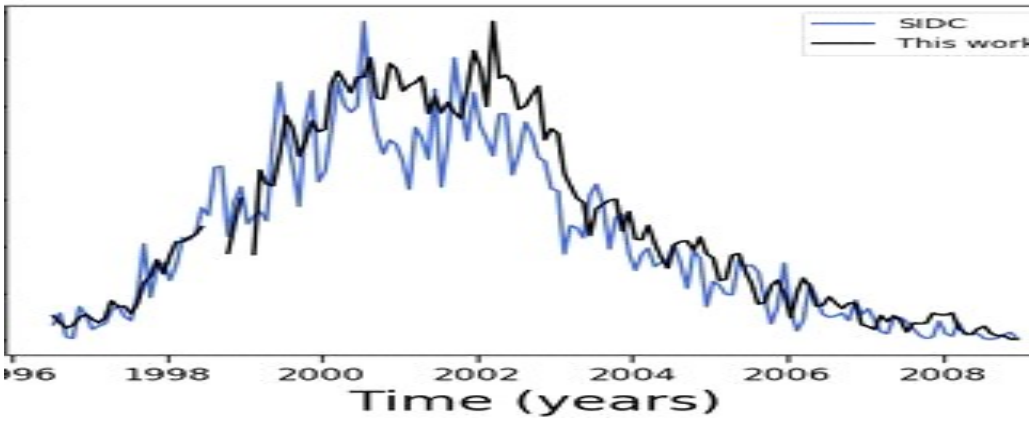
5. Case Studies of Major Storms

Detailed analyses were conducted on significant geomagnetic storms, including the Bastille Day storm (July 2001) and Halloween storms (October-November 2003). These case studies provided insights into the solar drivers and terrestrial impacts of extreme space weather.

Results and Discussion

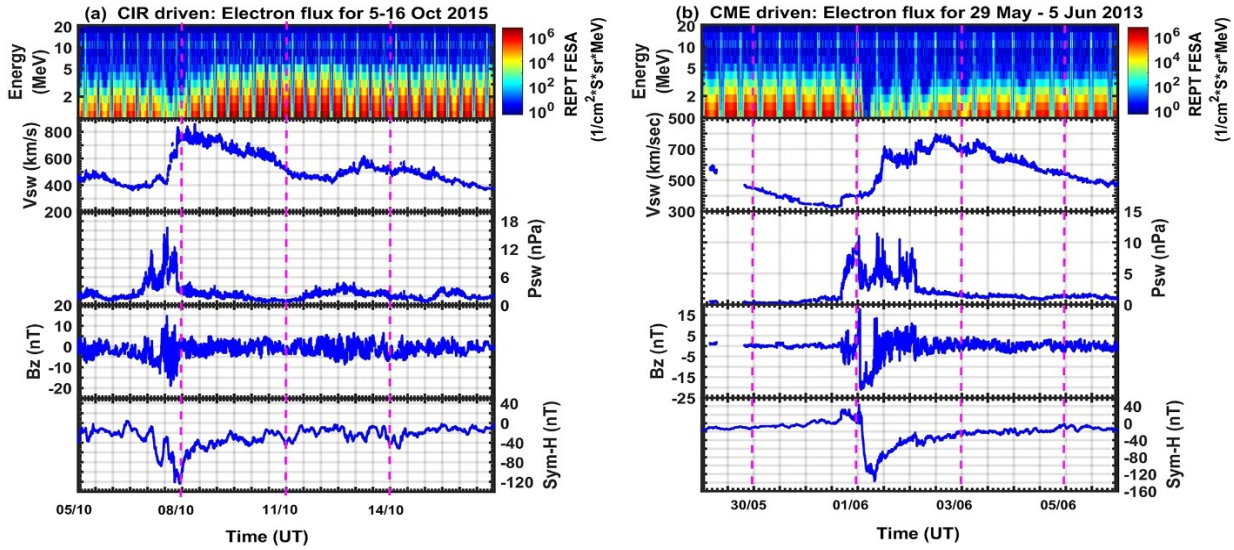
Solar Activity During Cycle 23

Solar cycle 23 exhibited moderate sunspot activity, with a maximum sunspot number of approximately 120 in 2001. The dual peak in solar activity, separated by about a year, indicated a temporary reduction in magnetic energy release, consistent with the Gnevyshev Gap phenomenon. The prolonged solar minimum from 2007 to 2009 was one of the deepest on record, with minimal sunspot activity and low soar irradiance. As shown in fig.below



Geomagnetic Activity Drivers

Analysis revealed that CMEs were the primary drivers of intense geomagnetic storms, particularly during the solar maximum. High-speed CMEs, often associated with X-class solar flares, caused significant disruptions to Earth's magnetosphere. Corotating interaction regions (CIRs), resulting from interactions between fast and slow solar wind streams, were more prominent during the declining phase and contributed to moderate, recurring geomagnetic storms. As shown in fig. below



Major Geomagnetic Events

* Bastille Day Storm (2001): A powerful CME triggered a severe geomagnetic storm, with a Dst index dropping below -300 nT. The storm caused satellite anomalies, auroral displays at low latitudes, and communication disruptions.
* Halloween Storms (2003): A series of CMEs launched during a period of intense solar activity resulted in one of the most disruptive space weather events of the cycle. These storms impacted satellite operations, aviation, and power grids. As shown in fig. 1

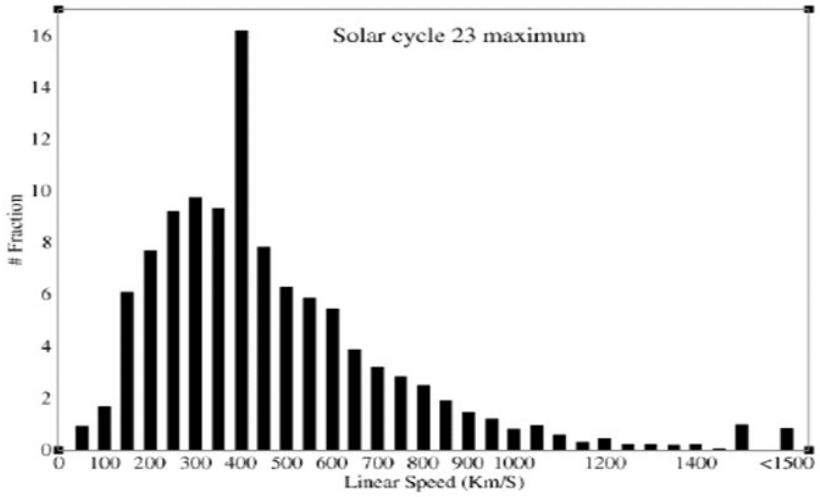


FIG. 1. **Showing how the number of CMEs distribute during 23 solar cycle.**

Space Weather Implications

The findings highlight a decoupling between sunspot numbers and geomagnetic storm intensity, underscoring the importance of CMEs and solar wind properties over traditional sunspot-based metrics. The prolonged solar minimum revealed the need for enhanced understanding of low-activity solar phases and their subtle impacts on Earth's space environment.

Conclusion

Solar cycle 23 demonstrated the complexity of solar-terrestrial interactions, emphasizing the dominant role of CMEs in driving geomagnetic disturbances. While sunspot activity was moderate, geomagnetic storms were intense, highlighting the necessity of improved predictive models for space weather. The prolonged solar minimum further underscored gaps in understanding solar behavior during quiet phases, calling for continuous monitoring and research. These findings are critical for mitigating the adverse impacts of space weather on modern technology and infrastructure.

References

1. Gopalswamy, N., & Yashiro, S. (2006). The Properties of Interplanetary Coronal Mass Ejections During Solar Cycle 23. Journal of Geophysical Research.
2. Lockwood, M., & Fröhlich, C. (2008). Recent oppositely directed trends in solar climate forcings and the global mean surface air temperature. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences.
3. Pulkkinen, T. (2007). Space weather: Terrestrial perspective. Living Reviews in Solar Physics.
4. NASA Solar Data Archives. Solar Cycle 23 Observations. Retrieved from [NASA Website].
5. Tsurutani, B. T., Gonzalez, W. D., & Gonzalez, A. L. C. (2003). Interplanetary origins of geomagnetic storms. Space Science Reviews.

Bioremediation of poly-aromatic hydrocarbon degradation under Aerobic Conditions: A Perspective Analysis

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ABSTRACT

Large spills should be recycled or eliminated to as great a degree as possible, but in some cases it is difficult to recover the spilled materials, resulting in its remaining in the affected area, and posing persistent risks to the environment. Bacteria displaying such capabilities are often exploited for the bioremediation of petroleum oil-contaminated environments. Recently, microbial remediation technology has developed rapidly and achieved major gains. However, this technology is not omnipotent. It is affected by many environmental factors that hinder its practical application, limiting the large-scale application of the technology. This paper provides an overview of the recent literature referring to the usage of bacteria as biodegraders, discusses barriers regarding the implementation of this microbial technology, and provides suggestions for further developments.
Keywords: hydrocarbon-degrading bacteria, bioremediation, bacterial enzymes.

INTRODUCTION

Petroleum oil is an important strategic resource for which all countries compete fiercely (1). Indeed, anthropogenic activity is reliant on oil to meet its energy demands, which causes the petrochemical industry to flourish. However, petroleum use results in environmental deterioration (2). During petroleum production, storage and transportation, refining and processing, as well as spills and discharges of petroleum hydrocarbons often occur as a result of blowout accidents during oilfield development, leakage from oil pipelines and storage tanks, oil tanker and tanker leakage accidents, oil well waxing, and during overhauls of refineries and petrochemical production equipment (3).

Accordingly, there is a constant threat of contamination wherever oil is exploited when coupled with an insufficient ability to deal with oil-contaminated environments, especially in extreme or unique environments such as polar regions, deep sea areas, deserts, and wetlands. Although oil pollution is difficult to treat, petroleum hydrocarbon-degrading bacteria have evolved as a result of existing in close proximity to naturally occurring petroleum hydrocarbons in the environment. Such organisms are candidates for the treatment of oil pollutants (4). Therefore, bacteria have been screened and utilized to degrade waste products produced by the food, agricultural, chemical and pharmaceutical industries. In recent years, the use of bacteria to deal with environmental pollutants has become a promising technology because of its low cost and eco-friendly nature (5). The continuous development and improvement of microbial remediation technology has also provided a new method for the remediation of petroleum hydrocarbon pollution, which has attracted much attention (6). The purpose of this review article is to provide some suggestions for the future development of bacterial remediation of petroleum hydrocarbons on the basis of previously published studies related to new advances in the area of bacterial remediation of petroleum hydrocarbons. Most petroleum hydrocarbons encountered in the environment are ultimately degraded or metabolized by indigenous bacteria because of their energetic and carbon needs for growth and reproduction, as well as the requirement to relieve physiological stress caused by the presence of petroleum hydrocarbons in the microbial bulk environment (4). The development of microbial biotechnology and high-throughput sequencing technology, such as microfluidic techniques (6), is beneficial for screening and identifying functional microorganisms from petroleum hydrocarbon-contaminated environments. Indeed, many studies have revealed that there is a large number of hydrocarbon-degrading bacteria in oil-rich environments, such as oil spill areas and oil reservoirs (7), and that their abundance

and quantity are closely related to the types of petroleum hydrocarbons and the surrounding environmental factors (8).

Many normal and extreme bacterial species have been isolated and utilized as biodegraders for dealing with petroleum hydrocarbons. The degradation pathways of a variety of petroleum hydrocarbons (e.g., aliphatics and polyaromatics) have been shown to employ oxidizing reactions; however, these pathways differ greatly because of the specific oxygenases found in different bacterial species. For instance, some bacteria can metabolize specific alkanes, while others break down aromatic or resin fractions of hydrocarbons. This phenomenon is related to the chemical structure of petroleum hydrocarbon components. Recent studies have identified bacteria from more than 79 genera that are capable of degrading petroleum hydrocarbons (9); several of these bacteria such as Achromobacter, Acinetobacter, Alkanindiges, Alteromonas, Arthrobacter, Burkholderia, Dietzia, Enterobacter, Kocuria, Marinobacter, Mycobacterium, Pandoraea, Pseudomonas, Staphylococcus, Streptobacillus, Streptococcus, and Rhodococcus have been found to play vital roles in petroleum hydrocarbon degradation (10). Interestingly, "conditionally rare taxa" in soil, such as Alkanindiges sp., have been reported to exhibit rare-to-dominant bacterial shifts that are strongly affected by environmental constrains such as diesel pollution (11). Similarly, some obligate hydrocarbonoclastic bacteria (OHCB), including Alcanivorax, Marinobacter, Thallassolituus, Cycloclasticus, Oleispira and a few others (the OHCB), showed a low abundance or undetectable status before pollution, but were found to be dominant after petroleum oil contamination (12). These phenomena suggest that these microorganisms are crucial to the degradation of petroleum hydrocarbons, and that they significantly influence the transformation and fate of petroleum hydrocarbons in the environment. Although some bacteria have been reported to have a broad spectrum of petroleum hydrocarbon degradation ability, Dietzia sp. DQ12-45-1b utilizes n-alkanes (C6-C40) and other compounds as the sole carbon sources (13) and Achromobacter xylosoxidans DN002 works well on a variety of monoaromatic and polyaromatic hydrocarbons (14), almost no bacteria can degrade the entire petroleum hydrocarbon fraction. Indeed, most bacteria can only effectively degrade or utilize certain petroleum hydrocarbon components, while others are completely unavailable (15). This can be attributed to the fact that different indigenous bacteria have different catalytic enzymes; thus, their roles in oil- contaminated sites also vary widely. This also implies that the remediation of petroleum hydrocarbon contamination requires the joint action of multiple functional bacteria to achieve the best environmental purification effect (16) constructed a halotolerant Hydrocarbon Utilizing Bacterial Consortium (HUBC) consisting of the bacterial isolates Ochrobactrum sp., Stenotrophomonas maltophilia and Pseudomonas aeruginosa that was found to be good at degrading crude oil (3% v/v), with a degradation percentage as high as 83.49%. (17) utilized a defined co-culture of an indigenous bacterial consortium and exogenous Bacillus subtilis to effectively accelerate the degradation of crude oil. Wang C. et al. (2018) found that an aboriginal bacterial consortium based on the Penglai 19-3 oil spill accident (China) had higher oil degradation efficiency compared to individual bacteria and demonstrated that this indigenous consortium had the potential for bioremediating crude oil dispersed in the marine ecosystem. A field study showed that bioaugmentation with an artificial consortium containing Aeromonas hydrophila, Alcaligenes xylosoxidans, Gordonia sp., Pseudomonas fluorescens, Pseudomonas putida, Rhodococcus equi, S. maltophilia, and Xanthomonas sp. contributed to high biodegradation efficiency (89%) in a 365-day treatment of diesel oil-contaminated soil (18). Taken together, these studies indicate that improving the biodegradation potential via the application of bacterial consortia possessing multiple catabolic genes is a reasonable and feasible strategy for accelerating the removal efficiency of petroleum hydrocarbons from contaminated environments.

TOXIC IMPACT OF PETROLEUM HYDROCARBONS

The harm that oil pollution causes to the ecological environment is well known (19). For example, the Deep Water Horizon oil spill accident in the Gulf of Mexico produced a profound impact on the economy and environmental safety, which is still the focus of people's attention (20). Although people are becoming increasingly concerned about the toxic effects of oil pollution on humans and animals in affected areas, the strong toxic impacts of petroleum hydrocarbons on affected microbial communities are often overlooked (21). reductions in species richness, evenness and phylogenetic diversity, with the resulting community being heavily dominated by a few species, principally Pseudomonas. Moreover, they found that the decline in richness and phylogenetic diversity was linked to the disruption of the nitrogen cycle, with species and functional genes involved in nitrification being significantly reduced (22) investigated the toxicity of

naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene as well as their oxygenated derivatives to bacterial cells of Agmenellum quadruplicatum, and found that these compounds produced no significant inhibitory effects on bacterial growth. However, the phenolic and quinonic naphthalene derivatives inhibited bacterial growth. This could be explained by phenols and quinones with higher solubility, enhancing the mass transfer of molecules to bacterial cells, resulting in higher toxic effects than the former compounds. Several studies have also reported that certain metabolic intermediates with relatively high solubility produced from the degradation of petroleum hydrocarbons by bacteria may have higher cytotoxicity than the parent molecules and therefore damage the bacteria. However, indigenous bacteria form very large aggregates, and each species has its own function. Accordingly, while some bacteria that are sensitive to petroleum hydrocarbons are greatly inhibited upon exposure to petroleum hydrocarbons, others that can efficiently degrade petroleum hydrocarbons, as well as bacteria that can take advantage of cytotoxic intermediate metabolites, will flourish. However, clean-up of petroleum oil pollutants by relying on the strength of these indigenous microorganisms alone will take a long time; therefore, it is necessary to develop intervention measures to speed the process up.

RESTRICTION OF PHYSICAL CONTACT BETWEEN BACTERIA AND PETROLEUM HYDROCARBONS

Due to the hydrophobicities and low water solubilities of most petroleum hydrocarbons, the biodegradation rate is generally limited in the environment. This is because the first step in the degradation process of petroleum oil often requires the participation of bacterial membrane-bound oxygenases, which require direct and effective contact between bacterial cells and petroleum hydrocarbon substrates. The primary factors restricting the biodegradation efficiency of petroleum hydrocarbons are as follows: (1) limited bioavailability of petroleum hydrocarbons to bacteria, and (2) the fact that bacterial cell contact with hydrocarbon substrates is a requirement before introduction of molecular oxygen into molecules by the functional oxygenases. However, bacteria have evolved countermeasures against petroleum contaminants, such as improving the adhesion ability of cells by altering their surface components and secreting bioemulsifier to enhance their access to target hydrocarbon substrates. Bacteria with such functions are often screened for use as environmental remediation agents, accelerating the removal of petroleum hydrocarbon pollutants from the environment (23).

Bacterial surface properties are essential to the effective biodegradation of hydrophobic hydrocarbon substrates and their adhesion mechanisms are of great importance found that adherence of hydrophobic pollutants to bacterial cells is mainly related to hydrophobic fimbriae, fibrils, outer-membrane proteins and lipids, as well as certain small molecules present in cell surfaces such as gramicidin S and prodigiosin. Fimbriae present on bacterial surfaces were confirmed to be necessary for the growth of Acinetobacter sp. RAG-1, with C16 alkane as the carbon source and beneficial to bacterial adherence, assimilation hydrophobic substrates and their metabolic activity (24). Nevertheless, bacterial capsules and several anionic exopolysaccharides produce inhibitory effects on hydrocarbon substrate adhesion. For example, Bacillus licheniformis decreases cell surface hydrophobicity in response to exposure to organic solvents and has little affinity for toxic organic compounds. Although bacterial adherence can enhance the biodegradation of hydrophobic hydrocarbons, it is not necessary to attach bacterial cells to targeted substrates. This is because, in some instances, bacteria with high surface hydrophobicity are easily aggregated and form biofilms, thereby producing potential risks such as diseases. Indeed, not only hydrophobic bacteria can biodegrade hydrophobic pollutants; several solvent-resistant hydrophilic bacteria are also capable of metabolizing such pollutants (26), which may be because of the modification of lipopolysaccharides or porines of the outer membrane of the bacterial surface also reported that the solvent-resistant bacteria were first to colonize and dominate for the removal of pollutants. Therefore, the use of hydrophilic microorganisms to treat hydrocarbon pollutants seems to be more advantageous than hydrophobic microorganisms (27). To enhance the bioavailability of petroleum hydrocarbons, one promising approach is the application of surfactants may enhance dissolution or desorption rates leading to the solubilization or emulsification of petroleum hydrocarbon pollutants found that the adherence of Bacillus sp. However, some surfactants, such as Corexit 9500, were reported to exhibit adverse impacts on oil-degrading bacteria of toxicity of the surfactant toward bacteria or as a result of competition of the surfactant with hydrocarbon substrates. In view of this, the selection of appropriate surfactants is of great importance for pollution remediation and the prevention of secondary pollution. Bioemulsifier-producing bacteria, which have attracted much attention, generally have the following two physiological aspects: (1) the ability to enhance the complexation and solubilization of non-polar substrates,

thereby promoting the bioavailability of substrates, and (28) the ability to improve affinity between cell surfaces and oil-water interfaces through metabolism, promoting deformation of the oil-water interface film (29) reported that the biosurfactant produced by Bacillus amyloliquefaciens An6 was an alternative to chemically synthesized surfactants since it showed high solubilization efficiency toward diesel oil (71.54% at 1 g/L) that was better than SDS and Tween 80 and could enhance the diesel oil degradation efficiency of the An6 strain. However, not all the biosurfactants produced by bioemulsifier-producing bacteria can effectively enhance the degradation rate of pollutants (30). Indeed, whether various biosurfactants stimulate or inhibit the bioremediation of pollutants is dependent on the physico-chemical properties of the surfactants, types of pollutants and physiological characteristics of the functional microorganisms (31). Therefore, it is necessary to establish a database of petroleum hydrocarbon pollutants and bioemulsifier-producing bacteria which is conducive to the targeted selection of suitable bacteria to treat with petroleum hydrocarbons.

ENVIRONMENTAL CONSTRAINTS

Many environmental factors such as temperature, nutrients, electron acceptors and substrates play vital roles in bioremediation and influence biodegradation reactions (32). This is why most researchers have found that many petroleum hydrocarbon-degrading bacteria can achieve excellent results during degradation of petroleum hydrocarbons under laboratory conditions yet exhibit dissatisfactory results in field-scale tests (33). The bacterial strains Acinetobacter sp. JLS1 and P. aeruginosa JLC1, isolated from Momoge wetlands in Jilin Province, China, showed different sensitivity to temperature during the biodegradation process of C16 alkane, suggesting that temperature strongly affected biodegradation efficiency (34). In a laboratory study, the petroleum hydrocarbons phenanthrene and dibenzothiophenes were well degraded, but similar degradation effects did not occur in a field experiment, which could be attributed to the temperature range during the study (35). Indeed, temperature can affect bacterial growth and metabolism, the soil matrix and the mode of occurrence of pollutants, thereby indirectly affecting biodegradation efficiency (36). It is well known that the growth of bacteria requires sufficient carbon, hydrogen, oxygen, nitrogen, sulfur, phosphorus, and various trace elements. However, the main components of petroleum hydrocarbons are only carbon and hydrogen, therefore the environment must have enough other nutrient elements to mensure growth of bacterial degraders. It is estimated that approximately 150 g of3 nitrogen and 30 g of phosphorous are consumed to convert 1 kg of hydrocarbons in bacterial cells (37). Extensive laboratory and field studies have been devoted to solving this problem. The addition of fertilizers containing bioavailable nitrogen and phosphorus has been successfully applied to stimulate petroleum oil biodegradation on a number of different shorelines and sandy beaches (38). Soluble and non-soluble nutrients suffer from problems in the actual remediation, leading to low bioremediation efficiencies (39). Researchers have found that using nitrogen-fixing hydrocarbon-degrading bacteria to improve the bioremediation efficiency was another good strategy instead of providing nitrogen sources (40). For aerobic degradation processes, using oxygen as an electron acceptor is quite important, but it is usually not adequate in petroleum oil-contaminated environments because of the limited air permeability. However, providing a sufficient oxygen supply to stimulate the bioremediation of petroleum pollutants in the environment is rather expensive and not feasible. Hence, the application of bulking agents such as saw dust into the soil to increase permeability or other electron acceptors (NO3?, Fe3+, or Mn2+) into anoxic environments to stimulate anaerobic microorganisms is often more economical than oxygen supplementation (41).

METABOLIC RESTRICTION

The ability to biodegrade petroleum oil is associated with the concentration and composition of hydrocarbons. Extremely high levels of petroleum hydrocarbons strongly inhibit bacterial growth, resulting in poor biodegradation efficiency and even death of the bacteria (42). This is related to the physico-chemical properties of the substrate and its bioavailability, which affect the contact, transport and transformation of bacteria to hydrocarbon substrates. The vast majority of indoor studies are focused on the degradation of a single substrate, but in nature the components of petroleum hydrocarbon pollutants are extremely complex. Accordingly, it is difficult to reproduce laboratory results in practical applications. For example, Pseudomonas putida F1 can efficiently mineralize benzene, toluene and phenol. While in the substrate mixtures, toluene and benzene enhance the biodegradation of phenol; however, phenol inhibits the biodegradation of benzene and toluene (43). The key components of bacterial degradation of petroleum hydrocarbons are various specific enzymes or example, the enzymes alkane 1-monooxygenase, alcohol dehydrogenase, cyclohexanol - dehydrogenase, methane monooxygenase and cyclohexanone 1,2 monooxygenase are involved in degradation of alkanes, while naphthalene 1,2-dioxygenase ferredoxin reductase component, cis-2,3-dihydrobiphenyl-2,3-diol dehydrogenase and

salicylaldehyde dehydrogenase are associated with naphthalene degradation and benzene dioxygenase, toluene dioxygenase and ethylbenzene dioxygenase work on other petroleum hydrocarbons (44).

Many isolated bacteria possess the ability to mineralize chemically simple petroleum hydrocarbons completely, such as linear alkanes, as long as these bacteria possess all of the enzymes for the targeted substrate (45). However, few bacteria can completely mineralize complex compounds such as resins and asphaltenes because of the lack of some enzymes (46). The advantages of microbial communities are presented because there are a variety of catabolic genes in a bacterial consortium, and the synergistic effects of these genes are beneficial to achieving the purification of pollutants (47). Researchers found that these five bacteria showed synergistic pyrene degradation due to the following aspects: (1) The Bacillus strain enhanced the bioavailability of the pyrene by producing biosurfactant, (2) two Mycobacterium strains contributed to the initiation of pyrene degradation, and (3) Novosphingobium and Ochrobactrum efficiently degraded the intermediates of pyrene. Given the complexity of the petroleum components, construction of the minimal functional bacterial consortium or genetic engineering bacteria for bioremediation of petroleum oil has become a trend in this field (48). However, the stability of the community and the safety of the engineered bacteria are additional problems that must be overcome.

CONCLUSION

Petroleum hydrocarbons are one of the most alarming pollutants due to their high toxicity to human and environmental health. Bioremediation with petroleum hydrocarbon-degrading bacteria is widely regarded as an eco-friendly and efficient technology. A large amount of bacterial species with petroleum hydrocarbon-degrading ability have been exploited and applied in bioremediation. However, various problems that slow down biodegradation effects have been found during the process of practical application. This review highlighted these restriction factors, including the toxic effects of petroleum hydrocarbons, the bioavailability of pollutants, environmental constraints, metabolic restrictions and time consumption, and then summarized the current countermeasures against these problems. Several strategies, such as regulating environmental factors and optimizing microbial inoculants, have been investigated and fulfilled. Based on the current state of knowledge reviewed here, a series of investigations still needs to be conducted prior to the successful application of bioremediation for the restoration of petroleum oil contaminated environments. It is concluded as follows: (1) Continue the theoretical basis of the interfacial interaction mechanism between bacteria and petroleum hydrocarbons in order to overcome barriers for microbial uptake of petroleum hydrocarbons, (2) develop novel biocompatible surfactants to enhance contact between bacteria and petroleum hydrocarbons, (3) explore undiscovered resources of petroleum hydrocarbon-degrading bacteria via new biotechnology, such as a high-throughput screening method to increase and enrich functional bacterial resources, (4) further optimize the strategy of artificial microbial consortia, such as by way of the metagenome enrichment approach to enrich and develop preferable consortia, (5) explore the novel functional genes controlling the pathway of hydrocarbon degradation to provide new looks on the molecular mechanism and microbial remediation, and (6) construct genetically engineered bacteria by using synthetic biology technology to give them more ability for petroleum hydrocarbon degradation.

REFERENCES

1. Abbasian, F., Lockington, R., Mallavarapu, M., and Naidu, R. (2015). A comprehensive review of aliphatic hydrocarbon biodegradation by bacteria. Appl. Biochem. Biotechnol. 176, 670-699. doi: 10.1007/s12010-015-1603-5
2. Abbasnezhad, H., Gray, M., and Foght, J. M. (2011). Influence of adhesion on aerobic biodegradation and bioremediation of liquid hydrocarbons. Appl. Microbiol. Biotechnol. 92, 653-675. doi: 10.1007/s00253-011-3589-4
3. Abed, R. M. M., Al-Kharusi, S., and Al-Hinai, M. (2015). Effect of biostimulation, temperature and salinity on respiration activities and bacterial community composition in an oil polluted desert soil. Int. Biodeterior. Biodegrad. 98, 43-52. doi: 10.1016/ j.ibiod.2014.1 1.018
4. Abuhamed, T., Bayraktar, E., Mehmetog?lu, T., and Mehmetog?lu, Ü. (2004). Kinetics model for growth of Pseudomonas putida F1 during benzene, toluene and phenol biodegradation. Process Biochem. 39, 983-988. doi: 10.1016/S0032- 9592(03)00210-3
5. Alabresm, A., Chen, Y. P., Decho, A. W., and Lead, J. (2018). A novel method for the synergistic remediation of oil-water mixtures using nanoparticles and oil- degrading bacteria. Sci. Total Environ. 630, 1292-1297. doi: 10.1016/ j.scitotenv. 2018.02.277
6. Ayed, H. B., Jemil, N., Maalej, H., Bayoudh, A., Hmidet, N., and Nasri, M. (2015). Enhancement of solubilization and

biodegradation of diesel oil by biosurfactant from Bacillus amyloliquefaciens An6. Int. Biodeterior. Biodegrad. 99, 8-14. doi: 10.1016/j.ibiod.2014.1 2.009

7. B. J., et al. (2018). Hydrocarbon degradation and response of seafloor sediment bacterial community in the northern Gulf of Mexico to light Louisiana sweet crude oil. ISME J. 12, 2532-2543. doi: 10.1038/s41396-018-01901
8. Brown, D. M., Okoro, S., van Gils, J., van Spanning, R., Bonte, M., Hutchings, T., et al. (2017). Comparison of landfarming amendments to improve bioremediation of petroleum hydrocarbons in Niger Delta soils. Sci. Total Environ. 596, 284-292. doi: 10.1016/ j.scitotenv.2017.04.072
9. Brown, L. M., Gunasekera, T. S., Striebich, R. C., and Ruiz, O. N. (2016). Draft genome sequence of Gordonia sihwensis strain 9, a branched alkane-degrading bacterium. Genome Announc. 4:e00622-16. doi: 10.1128/ genomeA.00622-16
10. Cerniglia, C. E., Freeman, J. P., Althaus, J. R., and van Baalen, C. (1983). Metabolism and toxicity of 1-and 2-methylnaphthalene and their derivatives in cyanobacteria. Arch. Microbiol. 136, 177-183. doi: 10.1007/BF00409840
11. Chaerun, S. K., Tazaki, K., Asada, R., and Kogure, K. (2004). Bioremediation of coastal areas 5 years after the Nakhodka oil spill in the Sea of Japan: isolation and characterization of hydrocarbon-degrading bacteria. Environ. Int. 30, 911-922. doi: 10.1016/j.envint.2004.02.007
12. Chen, M., Xu, P., Zeng, G., Yang, C., Huang, D., and Zhang, J. (2015). Bioremediation of soils contaminated with polycyclic aromatic hydrocarbons, petroleum, pesticides, chlorophenols and heavy metals by composting: applications, microbes and future research needs. Biotechnol. Adv. 33, 745-755. doi: 10.1016/ j.biotechadv.2015.05.003
13. Chen, W., Li, J., Sun, X., Min, J., and Hu, X. (2017). High efficiency degradation of alkanes and crude oil by a salt-tolerant bacterium Dietzia species CN-3. Int. Biodeterior. Biodegrad. 118, 110-118. doi: 10.1016/j.ibiod.2017.01.029
14. Chen, Y. J., Wang, H. Q., Wang, R., and Yun, Y. (2007). Effects of rhamnolipid on the biodegradation of n-hexadecane by microorganism and the cell surface hydrophobicity. Environ. Sci. 28, 2117-2122.
15. Díez, S., Jover, E., Bayona, J. M., and Albaigés, J. (2007). Prestige oil spill. III. Fate of a heavy oil in the marine environment. Environ. Sci. Technol. 41, 3075-3082. doi: 10.1021/es0629559
16. B. J. (2016). Reconstructing metabolic pathways of hydrocarbon-degrading bacteria from the Deepwater Horizon oil spill. Nat. Microbiol. 1:16057. doi: 10.1038/nmicrobiol.2016.57
17. Hoodaji, M., Tahmourespour, A., Abdollahi, A., Mohammadian- Baghi, T., Eslamian, S., et al. (2017). Bioremediation of polycyclic aromatic hydrocarbons by Bacillus Licheniformis ATHE9 and Bacillus Mojavensis ATHE13 as newly strains isolated from oil-contaminated soil. J. Geogr. Environ. Earth Sci. Int. 11, 1-11. doi: 10.9734/JGEESI/2017/35447
18. Fida, T. T., Moreno-Forero, S. K., Breugelmans, P., Heipieper, H. J., Röling, W. F., and Springael, D. (2017). Physiological and transcriptome response of the polycyclic aromatic hydrocarbon degrading Novosphingobium sp. LH128 after inoculation in soil. Environ. Sci. Technol. 51, 1570-1579. doi: 10.1021/acs.est. 6b03822
19. Fuentes, S., Barra, B., Caporaso, J. G., and Seeger, M. (2015). From rare to dominant: a fine-tuned soil bacterial bloom during petroleum hydrocarbon bioremediation. Appl. Environ. Microbiol. 82, 888-896. doi: 10.1128/AEM. 02625-15
20. Ghosal, D., Ghosh, S., Dutta, T. K., and Ahn, Y. (2016). Current state of knowledge in microbial degradation of polycyclic aromatic hydrocarbons (PAHs): a review. Front. Microbiol. 7:1369. doi: 10.3389/fmicb.2016.01369
21. Gogoi, B. K., Dutta, N. N., Goswami, P., and Mohan, T. K. (2003). A case study of bioremediation of petroleum-hydrocarbon contaminated soil at a crude oil spill site. Adv. Environ. Res. 7, 767-782. doi: 10.1016/S1093-0191(02)00029-1
22. Guerra, A. B., Oliveira, J. S., Silva-Portela, R. C., Araujo, W., Carlos, A. C., Vasconcelos, A. T. R., et al. (2018). Metagenome enrichment approach used for selection of oil-degrading bacteria consortia for drill cutting residue bioremediation. Environ. Pollut. 235, 869-880. doi: 10.1016/j.envpol.2018.01. 014
23. Gurav, R., Lyu, H., Ma, J., Tang, J., Liu, Q., and Zhang, H. (2017). Degradation of n-alkanes and PAHs from the heavy crude oil using salt-tolerant bacterial consortia and analysis of their catabolic genes. Environ. Sci. Pollut. Res. 24, 11392-

11403. doi: 10.1007/s11356-017-8446-2
24. Hara, A., Syutsubo, K., and Harayama, S. (2003). Alcanivorax which prevails in oil-contaminated seawater exhibits broad substrate specificity for alkane degradation. Environ. Microbiol. 5, 746-753. doi: 10.1046/j.1468-2920.2003. 00468.x
25. Hazen, T. C., Dubinsky, E. A., DeSantis, T. Z., Andersen, G. L., Piceno, Y. M., Singh, N., et al. (2010). Deep-sea oil plume enriches indigenous oil-degrading bacteria. Science 330, 204-208. doi: 10.1126/science.1195979
26. Hazen, T. C., Prince, R. C., and Mahmoudi, N. (2016). Marine oil biodegradation. Environ. Sci. Technol. 50, 2121-2129. doi: 10.1021/acs.est.5b03333
27. Head, I. M., Jones, D. M., and Röling, W. F. (2006). Marine microorganisms make a meal of oil. Nat. Rev. Microbiol. 4:173. doi: 10.1038/nrmicro 1348
28. Hedlund, B. P., Geiselbrecht, A. D., Bair, T. J., and Staley, J. T. (1999). Polycyclic aromatic hydrocarbon degradation by a new marine bacterium, Neptunomonas naphthovorans gen. nov., sp. nov. Appl. Environ. Microbiol. 65, 251-259.
29. Heipieper, H. J., Neumann, G., Cornelissen, S., and Meinhardt, F. (2007). Solvent- tolerant bacteria for biotransformations in two-phase fermentation systems. Appl. Microbiol. Biotechnol. 74, 961-973. doi: 10.1007/s00253-006-0833-4
30. Hou, N., Zhang, N., Jia, T., Sun, Y., Dai, Y., Wang, Q., et al. (2018). Biodegradation of phenanthrene by biodemulsifier-producing strain Achromobacter sp. LH-1 and the study on its metabolisms and fermentation kinetics. Ecotoxicol. Environ. Saf. 163, 205-214. doi: 10.1016/j.ecoenv.2018.07.064
31. Ceriello A, Bortolotti N, Falleti E, Taboga C, Tonutti L, Crescentini A, et al. Total radical-trapping antioxidant parameter in NIDDM patients. Diabetes Care 1997; 20:194-197.
32. Nishikawa T, Sasahara T, Kiritoshi S, Sonoda K, Senokuchi T, Matsuo T, et al. Evaluation of urinary 8-hydroxydeoxyguanosine as a novel biomarker of macrovascular complications in type 2 diabetes. Diabetes Care 2003; 26:1507-1512.
33. Hinokio Y, Suzuki S, Hirai M, Chiba M, Hirai A, Toyota T. Oxidative DNA damage in diabetes mellitus: its association with diabetic complications. Diabetologia 1999; 42:995-998.
34. Ceriello A, Sechi LA. Management of cardiovascular risk in diabetic patients: evolution or revolution? Diabetes Nutr Metab 2002; 15:121-127.
35. Giugliano D, Ceriello A, Paolisso G. Diabetes mellitus, hypertension, and cardiovascular disease: which role for oxidative stress? Metabolism 1995; 44:363-468.
36. Ceriello A. The possible role of postprandial hyperglycaemia in the pathogenesis of diabetic complications. Diabetologia 2003; 46 Suppl 1:M9-M16.
37. Brownlee M. Biochemistry and molecular cell biology of diabetic complications. Nature 2001; 414:813-820.
38. Du XL, Edelstein D, Rossetti L, Fantus IG, Goldberg H, Ziyadeh F, et al. Hyperglycemia-induced mitochondrial superoxide overproduction activates the hexosamine pathway and induces plasminogen activator inhibitor-1 expression by increasing Sp1 glycosylation. Proc Natl Acad Sci USA 2000; 97:122-136.
39. Nishikawa T, Edelstein D, Du XL, Yamagishi S, Matsumura T, Kaneda Y, et al. Normalizing mitochondrial superoxide production blocks three pathways of hyperglycaemic damage. Nature 2000; 404:787-790.
40. Baynes JW. Role of oxidative stress in development of complications in diabetes. Diabetes 1991; 40:405-412.
41. Ceriello A, Morocutti A, Mercuri F, Quagliaro L, Moro M, Damante G, et al. Defective intracellular antioxidant enzyme production in type 1 diabetic patients with nephropathy. Diabetes 2000; 49 : 2170-2172.
42. Hodgkinson AD, Bartlett T, Oates PJ, Millward BA, Demaine AG. The response of antioxidant genes to hyperglycemia is abnormal in patients with type 1 diabetes and diabetic nephropathy. Diabetes 2003; 52:846-861.
43. Marfella R, Verrazzo G, Acampora R, La Marca C, Giunta R, Lucarelli C, et al. Glutathione reverses systemic hemodynamic changes induced by acute hyperglycemia in healthy subjects. Am J Physiol 1995; 268:E1167-1173.
44. Ting HH, Timimi FK, Boles KS, Creager SJ, Ganz P, Creager MA. Vitamin C improves endothelium-dependent vasodilation in patients with non-insulin-dependent diabetes mellitus. J Clin Invest 1996; 97:22-38.
45. Tesfamariam B, Cohen RA. Free radicals mediate

endothelial cell dysfunction caused by elevated glucose. Am J Physiol 1992; 263:321-326.

46. Diederich D, Skopec J, Diederich A, Dai FX. Endothelial dysfunction in mesenteric resistance arteries of diabetic rats: role of free radicals. Am J Physiol 1994; 266:1153-1161.
47. Asplund K. Antioxidant vitamins in the prevention of cardiovascular disease: a systematic review. J Intern Med 2002; 251:372-392.
48. Marchioli R, Schweiger C, Levantesi G, Tavazzi L, Valagussa F. Antioxidant vitamins and prevention of cardiovascular disease: epidemiological and clinical trial data. Lipids 2001; 36:S53-563.
49. Cuzzocrea S, Riley DP, Caputi AP, Salvemini D. Antioxidant therapy: a new pharmacological approach in shock, inflammation, and ischemia/ reperfusion injury. Pharmacol Rev 2001; 53:135-159.
50. Shor-Posner G, Lecusay R, Morales G, Campa A, Miguez-Burbano MJ. Neuroprotection in HIV-positive drug users: implications for antioxidant therapy. J Acquir Immune Defic Syndr 2002; 31 Suppl 2:S84-98.
51. Gilgun-Sherki Y, Rosenbaum Z, Melamed E, Offen D. Antioxidant therapy in acute central nervous system injury: current state. Pharmacol Rev 2002; 54:271-284.
52. Gammer W, Broback LG. Clinical comparison of orgotein and methylprednisolone acetate in the treatment of osteoarthrosis of the knee joint. Scand J Rheumatol 1984;13:108-112.
53. Goebel KM, Storck U. Effect of intra-articular orgotein versus a corticosteroid on rheumatoid arthritis of the knees. Am J Med 1983; 74:124-128.
54. Salvemini D, Muscoli C, Riley DP, Cuzzocrea S. Superoxide dismutase mimetics. Pulm Pharmacol Ther 2002; 15:439-447.
55. Salvemini D, Riley DP, Cuzzocrea S. SOD mimetics are coming of age. Nat Rev Drug Discov 2002; 1:367-374.
56. Lango R, Smolenski RT, Narkiewicz M, Suchorzewska J, Lysiak-Szydlowska W. Influence of L-carnitine and its derivatives on myocardial metabolism and function in ischemic heart disease and during cardiopulmonary bypass. Cardiovasc Res 2001; 51:21-29.
57. Midaoui AE, Elimadi A, Wu L, Haddad PS, de Champlain J. Lipoic acid prevents hypertension, hyperglycemia, and the increase in heart mitochondrial superoxide production Am J Hypertens 2003; 16:173-179.
58. Ceriello A. New insights on oxidative stress and diabetic complications may lead to a "causal" antioxidant therapy. Diabetes Care 2003; 26:1589-1896.
59. Kelly DJ, Zhang Y, Hepper C, Gow RM, Jaworski K, Kemp BE, et al. Protein kinase C beta inhibition attenuates the progression of experimental diabetic nephropathy in the presence of continued hypertension. Diabetes 2003; 52:512-518.
60. Cotter MA, Jack AM, Cameron NE. Effects of the protein kinase C beta inhibitor LY333531 on neural and vascular function in rats with streptozotocin-induced diabetes. Clin Sci (Lond) 2002; 103:311-321.
61. Pacher P, Mabley JG, Soriano FG, Liaudet L, Komjati K, Szabo C. Endothelial dysfunction in aging animals:the role of poly(ADP-ribose) polymerase activation. Br J Pharmacol 2002; 135:1347-1350.
62. Szabo C, Mabley JG, Moeller SM, Shimanovich R, Pacher P, Virag L, et al. Part I: pathogenetic role of peroxynitrite in the development of diabetes and diabetic vascular complications: Sstudies with FP15, a novel potent peroxynitrite decomposition catalyst. Mol Med 2002; 8:571-580.
63. Shiojiri T, Wada K, Nakajima A, Katayama K, Shibuya A, Kudo C, et al. PPAR gamma ligands inhibit nitrotyrosine formation and inflammatory mediator expressions in adjuvant- induced rheumatoid arthritis mice. Eur J Pharmacol 2002; 448:231-238.
64. Dobrucki LW, Kalinowski L, Dobrucki IT, Malinski T. Statinstimulated nitric oxide release from endothelium. Med Sci Monit 2001; 7:622-627.
65. Ceriello A, Taboga C, Tonutti L, Quagliaro L, Piconi L, Bais B, et al. Evidence for an independent and cumulative effect of postprandial hypertriglyceridemia and hyperglycemia on endothelial dysfunction and oxidative stress generation: effects of short- and long-term simvastatin treatent. Circulation 2002; 106:1211-1218.
66. Takemoto M, Node K, Nakagami H, Liao Y, Grimm M, Takemoto Y, et al. Statins as antioxidant therapy for preventing cardiac myocyte hypertrophy. J Clin Invest 2001; 108:1429-1437.

A Review of the Photonic Application of Quantum Dot Doped Liquid Crystal

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Abstract:
The present review presents the electro-optical properties of quantum dot doped liquid crystal (LC) with a wide range of frequency. Mesogenic ligands have the potential to provide control over the dispersion and stabilization of nanoparticles in liquid crystal (LC) phases. The creation of such hybrid materials is an important goal for the creation of soft tunable photonic devices. Ligands exchange of QDs that was performed by oleic acid (OA) substitution with liquid crystal (LC) molecules have explained. Different quantum dots used in this study including non-mesogenic ODA ligands and the LC ligands. Possible mechanisms of the interaction between NLC molecules and TiO2 NPs are discussed. The present work shows that the TiO2 NPs doping has a promising application in the display devices, electro-optical as well as photonic applications.
Keywords: Liquid Crystal; Ligand; Polymer; Photoluminescence; Birefringence; PDLC.

Introduction : In this review, we present recent results on the photonic properties and applications of six scientifically interesting and technologically important materials; 4'-octyl-4-biphenylcarbonitrile (8CB) with CdSe/CdS/ZnS Quantum dots(QDs)[1], 4 cyano-4'-pentylbiphenyl (5CB) with QDs [2], nematic liquid crystal E7 and colloidal QDs with polymer matrix(QD-PDLCs)[3], liquid crystal polymer matrix containing CdSe QD[4], ZnS QDs and ferroelectric liquid crystal(SCE4) composites[5], pristine and Cd1-xZnxS/ZnS QDs dispersed nematic LC, p-Butoxybenzylidene, p-heptylaniline (BBHA)[6]. Over the past few decades colloidal quantum dots (QDs) have received significant interest because of their potential interest in photonics. The QDs have unique size tunable properties due to quantum confinement effect in nanosize regime (2-10nm). The field of liquid crystals has much benefitting with the advancement of nanomaterials. Recently a large amount of work has been executed with the hybrid mixtures of liquid crstal and nonmaterials [7]. Liquid crystal materials are the materials whose molecular alignment can be controlled with the use of electric and magnetic fields. Different nanoparticle stabilize the twist grain boundary phases and defects rich blue phases in nanoparticle /liquid crystal material [8-10].The main problem in designing the photonic devices by using nanoparticle/liquid crystal mixture is the stabilization of composite material over a long range of time. Bare nanoparticles in the crystals exhibit the particle aggregation and complete separation from the solvent in nanoparticle /liquid crystal composites. To define the alignment of liquid crystal molecules the surface ligands can be carefully designed between particle and solvent [1-5]. The ligands selection effect the quality of QDs [9-13].Yu and co-workers have reported several synthesis of a series of CdSe nanocrystals by choosing distinct precursors in various ratios as well as careful ligands choice[14-15]. Here the modification of photonic effects in liquid crystal/nanoparticle composite material is the main consideration. This review mainly focuses on the application of semiconductor nanoparticles (also known as quantum dots) as dopant in the liquid crystalline phase.

Semiconductor quantum dots (QDs) are being extensively developed and studied for the application in medicine [16] photonics [16-18] and other QDs based devices. The unique size (2-10nm) and shape dependent optical properties of QDs attributed to quantum confinement effect. Utilizing LCs as templates for the synthesis can offer remarkable advantages including the ability to control the size and shape of nanomaterials simultaneously by choosing different mesophases and LC compositions.

The review is organized as follows: We begin by introduction to the quantum dot doped liquid crystal (QD-LC) composite material and their applicability. We then discuss the ligands exchange phenomena QD-LC systems reported in the literature that emerge from the combination of q-dots and LCs. Since liquid crystals are mostly used in display applications, we will discuss the effects of dissolved quantum dots on their performance, e.g., on stability, birefringence, photoluminescence, emission and absorption spectra etc. After that we will describe effects of quantum dot on polymer dispersed liquid crystal system, on LC alignment and the corresponding effect on photonic properties so far are exciting and show promise for having a major impact on

display applications. The utility of such particles in ferroelectric liquid crystal displays, optical scattering, photoluminescence, and directed self-aggregation is also discussed.

1. Results and discussion

2.1 Ligands exchange: modulation of the photonic properties of quantum dots (QDs)/liquid crystal composite materials

Besides the fact the optical properties are tuned with size control of the QDs, the various problems are related with the surface of the QDs. Surface traps are found at the QDs surface which causes the emission at higher frequencies than expected frequency. Ligands selection is one of the important aspect having a considerable effect on the QDs can induce different physicsl and chemical effects and it is necessary for the surface to be premodified for a desired applications [8-10].

2.1.1 Stability and Optical properties of QD-LC system: A J Al-Alwani et al.[1] has replace the Oleic acid (OA) ligands with ligands of 4'-octyl-biphenylcarbonitrile (8CB) LC to modify and control the photonic properties of CdSe/CdS/ZnS Qd:LC mixture. A mixture of QD: LC was prepared at different ratios 1:1 and 1:2.

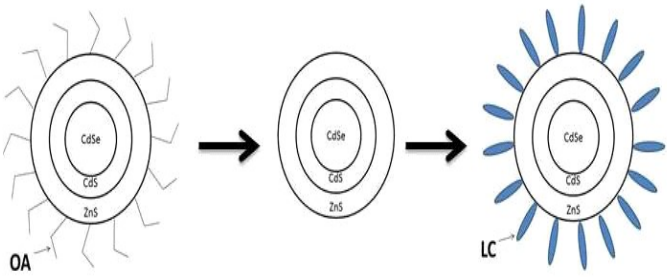


Figure 1. Schematic representation of ligands exchange of QDs that was performed by oleic acid (OA) substitution with liquid crystal (LC) molecules. (Adapted from ref. 1- IOP Publishing)

AJ Al-Alwani et al.[1] obtain emission and excitation spectra of the four samples (i) QDs with OA ligands (ii) QDs without OA ligands (iii) QD:LC mixture in the ratio 1:1 (iv) QD:LC mixture in the ratio 1:2. The emission and excitation spectra of QDs without OA ligands have shown red shifting to 623.5 and 640 nm respectively. This longer wavelength side shifting suggests that QDs become unstabilised and aggregated without OA ligands. It means increased physical size of QDs.

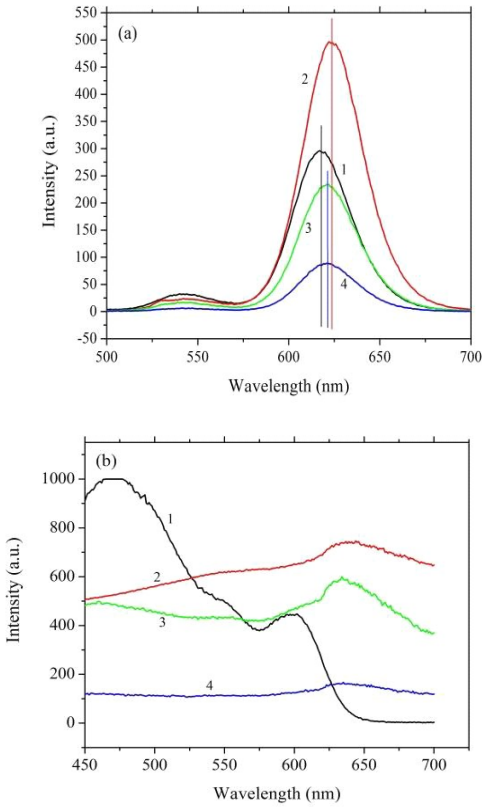


Figure 2. Emission spectra (a) and excitation spectra (b) for solutions of QDs with OA stabilizer (1) QDs solution without OA stabilizer (2), QDs:LC 1:1 (3) and QDs:LC 1:2 (4).(Adapted from ref. 1-IOP Publishing)

The authors confirmed that emission and excitation intensity of QD:LC mixture at a ratio 1:1 and 1:2 shifted to 621.2 nm and 634 nm. For explanation of these findings the author gave the example of reference [19-20]. This research paper tells that changing in the refractive index can cause a red or blue shift in spectra of QDs. The author had claims that designing surface modified QDs in LC phases is an important role in the photonic application that requires soft switchable materials.

2.1.2 QD-LC Photonic application: In another experiment Andrea L. Rodarte et al. [2] was performed experiment to investigate the effect of mesogenic ligands on photonic properties of QD/LC hybrid material (4 cyano-4'-pentylbiphenyl (5CB) with QDs). In Octadecylamine (ODA)-QDs a ligands exchange was performed on core only and core-shell QDs. They prepared four samples (i) core only QD +ODA (ii) core-shell QD+ODA (iii) core only QD + LC (iv)core-shell QD +LC

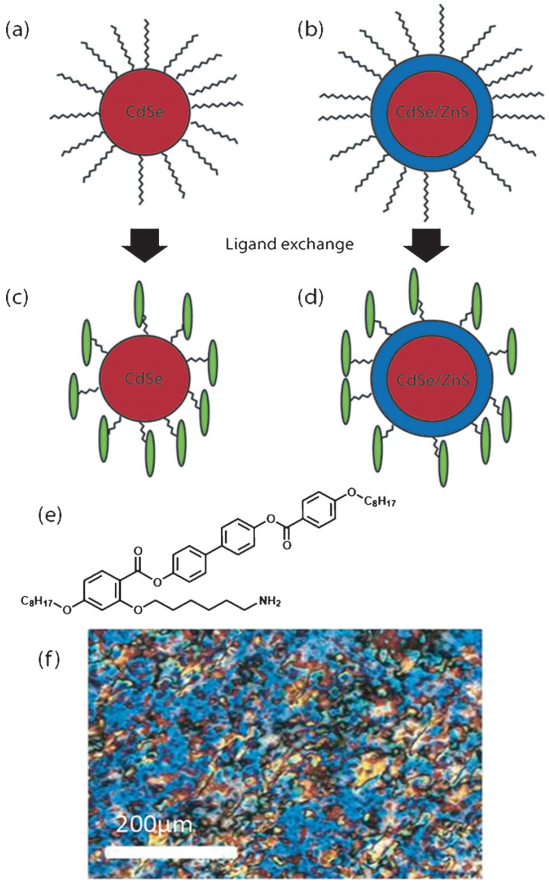


Figure 3. Schematic representation of a-d) the different quantum dots used in this study including non-mesogenic ODA ligands and the LC ligands (green). e) Molecular structure of the mesogenic ligands (11) and f) nematic phase of 11 at 130 0C, imaged by using polarized optical microscopy. (Adapted from ref. 2- ChemPubSoc. Europe)

The authors had demonstrated absorption and emission spectra for core only and core-shell QDs with ODA and mesogenic ligands.

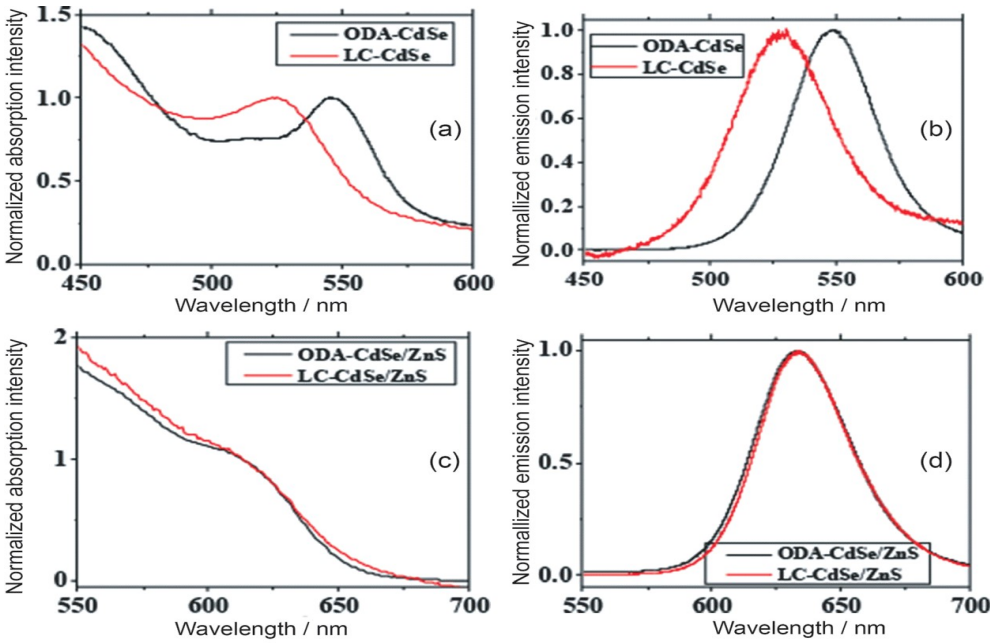


Figure 4. Absorption (a, c) and emission (b, d) spectra for ODA- and LC-QDs in toluene with core-only (a and b) and core/shell (c and d) QDs. Each graph shows spectra taken before and after the ligands exchange.(Adapted from ref 2 ChemPubSoc Europe).

In absorption and emission spectra the core only QDs showed the blue shift after ligands exchange [fig 4]. However there is no any significant change after ligands exchange in core-shell QDs. The authors had claimed that for core only QDs, the particles are highly susceptible to core oxidation of QDs. Besides this the emission intensity of core only QDs after ligands exchange was significantly reduced. This is attributed to the trap of electrons due to surface defects states which quenching the PL emission. Based on this, they report that where stability and quantum efficiency are important we should prefer core-shell QDs for photonic application

They [2] also investigate the dispersion of QDs in nematic LC(5CB) host with the ultimate goal to use in photonic applications. Mixtures were prepared at differet QD concentration in 5CB and imaged using fluorescene microscopy over a range of different concentrations from 0.02 wt% up to 0.15 wt%.

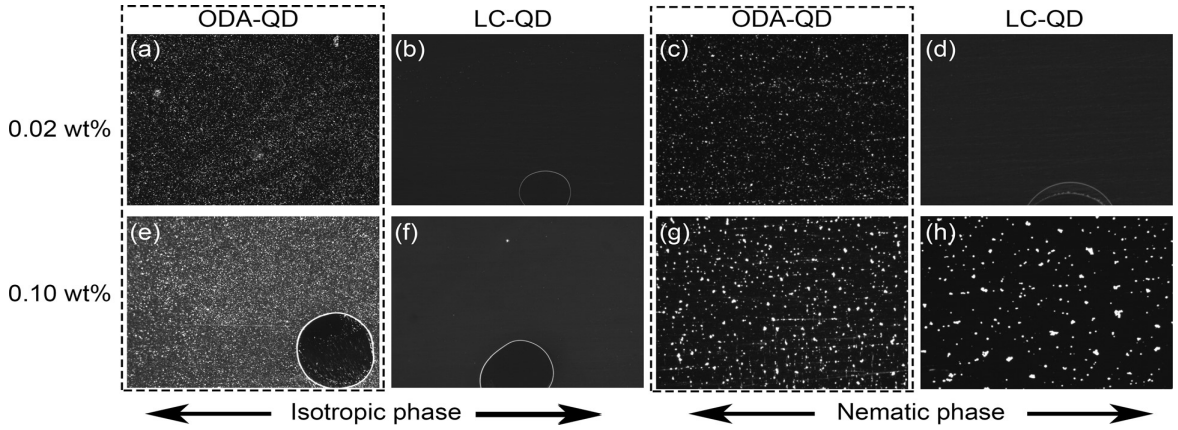


Figure 5. Fluorescence microscopy images of different surface-functionalized QDs in the isotropic and nematic LC phase (5CB). a) ODA-QD, 0.02 wt%, isotropic. b) LC-QD, 0.02 wt% isotropic. c) ODA-QD, 0.02 wt%, nematic. d) LC-QD, 0.02 wt%, nematic. e) ODA-QD, 0.10 wt%, isotropic. f) LC-QD, 0.10 wt% isotropic. g) ODA-QD, 0.10 wt%, nematic and h) LC-QD, 0.10 wt%, nematic. (Adapted from ref. 2-ChemPubSoc, Europe).

Figure 5 (a,b,e,f) demonstrate that in the isotropic phase the LC-QDs showed enhanced dispersion at both 0.02 wt% and 0.10 wt% with no large clusters visible under the microscope. They observed that the ODA-QDs were only fully dispersed in the isotropic phase at concentration < 0.05 wt% with sonication time of upto 19 hrs. in comparison, the LC-QD dispersed well upto concentration of 0.15 wt% with a 6 hrs sonication time .

The authors also compare the differences between ODA-QDs and LC-QDs in the nematic pase(figure5; c,d,g,h). At the lower concentration (0.022 wt %), LC-QDs dispersed uniformely but ODA-QDs do not ; microsized QDs cluster formed throughout the material. They observed that the cluster size is a function of cooling rate (from the isotropic to nematic phase) and concentration. For nanoscale particles in a liquid crystal entropic effects arising from discrete interactions between surface ligands and surface-localised LC molecule become increasingly important to phase behavior [21]. The authors had found the similar results by performing scanning confocal PL microscopy [22-24].

They have also investigated the emission intensity of ODA-QD and LC-QD with cholesteric liquid crystal. In cholesteric devices embedded QD can act as emitters coupled to a tunable fluid cavity. The figure 6 showed the emission spectra (separated in to left and right circular polarization) of doped QDs and cholesteric stop band. The emission spectra reveal clear resonance with the cholesteric cavity for the right handed component only.

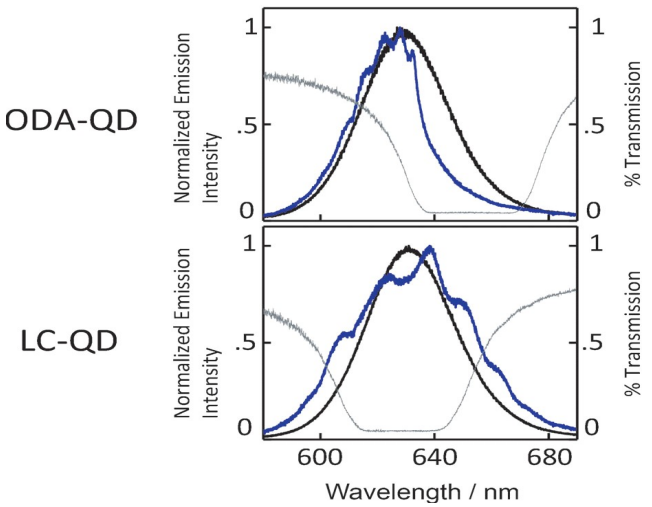


Figure 6. Emission spectra for ODA- and LC-QDs dispersed in a cholesteric material at 0.1 wt% and separated into lefthanded (black peak) and right-handed (blue peak) components. The cholesteric stop band (transmission spectrum) is also shown (grey) for the righthanded component. (Adapted from ref. 2- ChemPubSoc, Europe).

Our group [5] also reported the PL emission of a ZnS quantum dot as represented in Fig. 7. The Quantum dots emit strongly with a maximum at 420nm with an excitation wavelength of 350nm. The blue emission centered at 420nm is associated with the luminescence from the self-activated centers. These centers have often been attributed to crystal lattice vacancies [25].

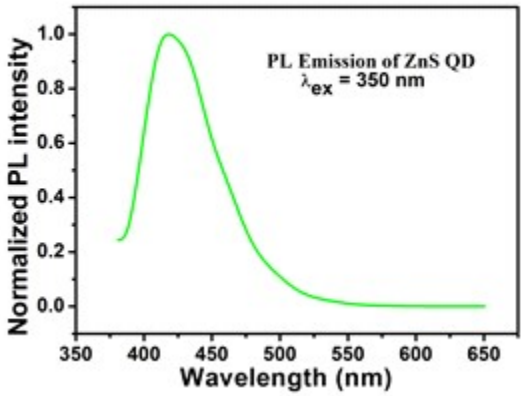
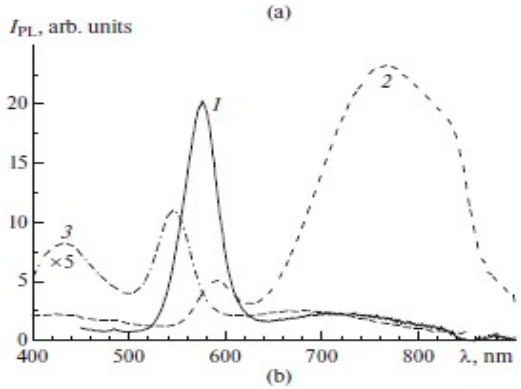


Fig. 7. PL emission spectra of ZnS quantum dot.(adapted from ref 5 photonic society of Poland)

1.2 Photoluminescent spectrum of quantum dots of cadmium selenide (CdSe) in liquid crystalline matrix:

Polymer dispersed liquid crystal (PDLC) film attracted much importance due to its scattering properties. Quantum dos embedded Polymer dispersed liquid crystals (QD-PDLC) are important for liquid crystal based display technology.

2.2.1 Quantum dot-polymer dispersed liquid crystal (QD-PDLC) system: With the goal of tuning the photonic properties A V Elopov et al.[4]studied the QD nanocomposites in a liquid crystalline polymer (LCP) matrix and measured their photoluminscene(PL) spectra. They found the PL spectra of solution of CdSe QDs and for CdSe QDs in LCPs and amorphous polymer matrices as shown in following figure 8.



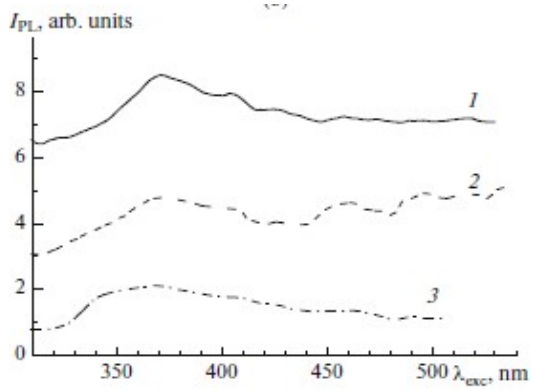


Fig. 8. (a) PL spectra of (1) CdSe QDs and nanocomposites with a CdSe QD mass fraction of 15% in (2) LCP and (3) amorphous polymer matrices when excited by radiation with a wavelength of 368 nm. (b) PL excitation spectra of (1) CdSe QDs and nanocomposites with a CdSe QD mass fraction of 15% in (2) LCP and (3) amorphous polymer matrices, recorded at wavelengths of 576, 595, and 545 nm, respectively. (Adapted from ref. 4- published in Izvestiya Rossiiskoi Akademii Nauk, Seriya, Fizicheskaya)

This paper reported two bands at wavelength 576 nm and 730 nm for the solution of CdSe QDs. When we compare PL spectra for CdSe QDs with LCP matrix and with amorphous polymer matrix then it have found that in LCP matrix it shifted towards lower photon energies and for amorphous polymer matrix it shifted towards higher energies. At the concentration below the 1 wt% the PL bands were not detected. Short wavelength PL band and long wavelength band were explained on the basis of radiative recombination of excitons and levels of surface defects [26-27].They also find the PL excitation spectra excited by Laser pulse for all samples and found that the PL spectra band observed at a concentration of QDs above 3 wt% ; its intensity grew along with the concentration of QDs.

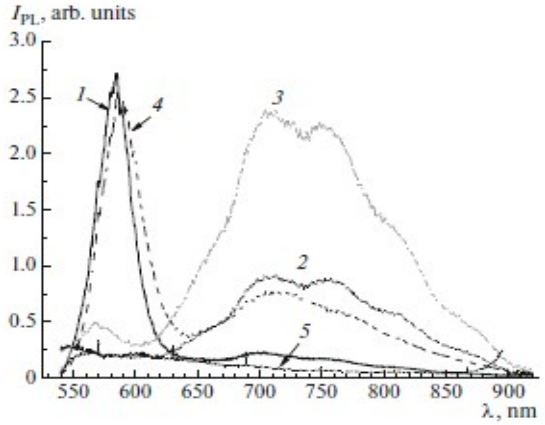


Fig. 9. PL spectra of (1) CdSe QD sol; of CdSe QDs in LCP matrices with concentrations of (2) 5, (3) 10, and (4) 30 wt %; and of (5) LC polymer when excited by laser pulses with a wavelength of 532 nm. (Adapted from ref. 4- published in Izvestiya Rossiiskoi Akademii Nauk, Seriya, Fizicheskaya)

The authors find the result after the Laser pulse action at different set of times and showed that there was no notable shift of peak at different times of spectrum removal. It was seen that the life time of the exciton band was shortened upon an increase in QD concentration with an LC polymer. The use of an amorphous polymer as a matrix shortened the PL life time, compared to nanocomposite with an LCP. These facts testify to the advantageous of using an LC polymer to create nanocomposite with CdSe Qds.

2.2.2 Amplified spontaneous emission (ASE) in a QD-PDLC system: Mingxuam cao et al.[3] reports the enhanced amplified spontaneous emission in a QD doped PDLC system . They used nematic liquid crystal E7 and colloidal QDs with polymer matrix (QD-PDLCs) for their study. They observe that the low concentration of QDs (<0.25 %) in liquid crystals makes it difficult to form so optically dense medium that generates stimulated emission[28-31]. Therefore QDs doped polymer dispersed liquid crystal QD-PDLC system was used which solve the low concentration problem of QDs in LCs. Cavalieri s etal.[32] showed that when medium size PDLCs droplets dispersed in the polymer matrix then they have strong scattering effect. This scattering effect is due to mismatch between refractive indices of LC droplets and polymer matrix[32].

Mingxuam cao et al.[3] was used CdSe/ZnS QDs(with a CdSe core and ZnS shell) with PDLC mixture of nematic liquid crystal (E7) and acrylic resin. The ordinary and extraordinary refractive indices of E7 were 1.52 and 1.72 and that of acrylic resin 1.52. The capillary tube filled with QD-PDLCs were exposed using an ultraviolet lamp (20mW cm-2). The authors ploted the graph showing PL of the QD-PDLCs under a pump energy from 1 to 20 mJ cm-2

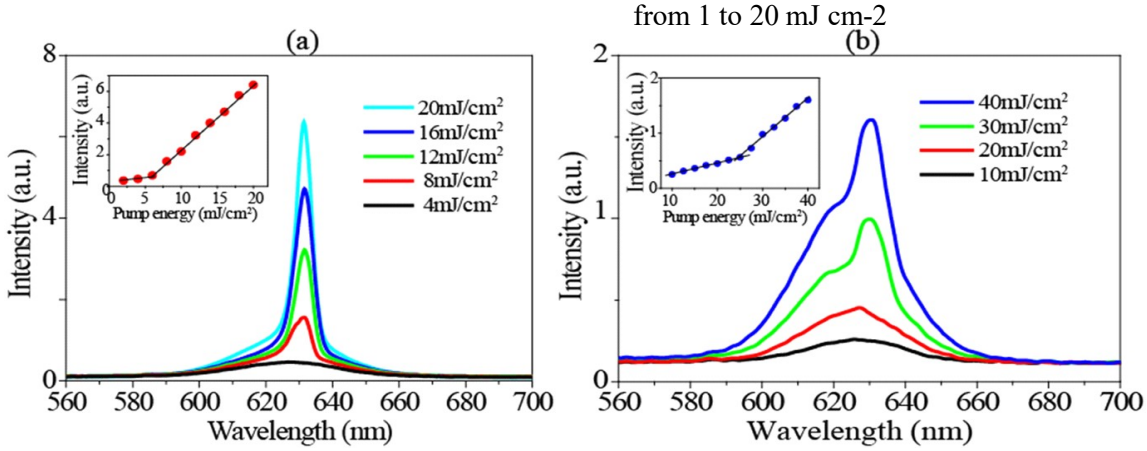


Figure 10. Emission spectra of (a) the QD-PDLCs and (b) the QD-acrylic resin with increasing pump energy; the insets show evolution of the peak intensity as a function of pump energy.(Adapted from ref. 3-IOP Publishing).

The authors found that the threshold for amplified stimulated emission (ASE) for QD-acrylic resin was much higher (25 mJcm-2) than the threshold for QD-PDLC (6 mJcm-2). The path length or the dwell time of light considerably increased due to mutiscattering from LC droplets which leads to decrease in the threshold for the stimulated emission. The authors proposed that this system highlights a simple way to enable QDs to work effectively with LC, which has potential applications for random fiber lasers and laser amplifiers.

2.2.3 QD-LC, Birefringence: P.K.Tripathi et al. [6] dispersed Cd1-xZnxS/ZnS QDs into nematic LC BBHA and have investigated the influence of QDs dispersion, its concentration in nematic matrix and applied voltage on the electrooptical properties of pure and QDs dispersed nematics. This study has been carried out with the sole aim to make the dispersed nematic system friendlier for the applications of nematic based devices. They studied the effects of applied voltage, temperature and concentration of QDs in nematic matrix on the switching behaviour and birefringence of pristine and dispersed systems and have observed that when a bias of 28 V is applied the response time decreases about 60% in the case of dispersed system. They also found that response time decreases rapidly with the increase of temperature and concentration of dispersion of QDs. These finding show that dispersion of QDs in nematic matrix is of advantage from the application point of view of nematic LC based devices.

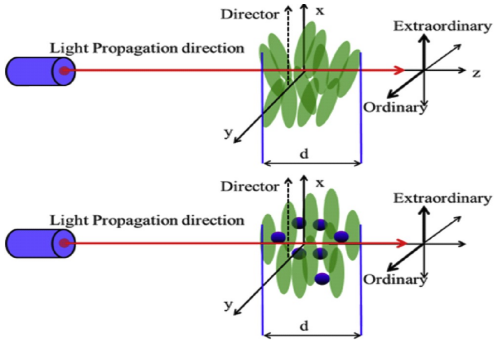


Figure 11. Schematic diagram of pristine and QDs dispersed nematics. (Adapted from ref 6 Elsevier).

The birefringence of nematic depends on the applied voltage, wavelength and temperature. Figure 12 shows the variation of birefringence with the temperature. The values of birefringence remain almost constant upto 540C and 75 0C, respectively, for the pure and QDs dispersed nematics and beyond 75 0C its value decreases with increase in temperature and vanishes in isotropic phase. The birefringence of QDs dispersed nematic increases with the increase in the concentration of QDs in nematic matrix and slowly decreases near the nematic-isotropic transition temperature. As the birefringence of QDs dispersed nematic has increased as compared to pristine nematic, it suggests that due to the alignment of nematic molecules the transmitted light has larger phase difference as compared to pristine nematic molecules. In order to develop understanding we propose a schematic arrangement of molecules as shown in figure 11. It can be seen that due to dispersion of QDs the orientation order has been increased. Due to large birefringence, the QDs dispersed nematic finds a variety of uses such as in phase shifters and reconfigurable antennas. So we can tune the desired phase difference more accurately, using QDs dispersed nematics [6].

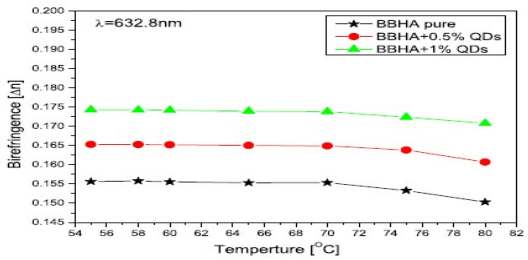


Figure 12. Variation of birefringence (n) with temperature for pristine and QD dispersed nematic systems.(Adapted from the ref. 6-Elsevier)

2.2.4 Ferroelectric liquid crystal and QDs; composite material: Our group i.e. Tripti et al. [5] performed the experiment with ZnS QDs and ferroelectric liquid crystal (FLC-SCE4) composites. The samples were prepared by dispersing an appropriate amount of ZnS QDs {Mix.1 (0.25 wt. /wt. %) and Mix.2 (0.5 wt. /wt. %)} into a pure FLC material and homogenized by an ultrasonic mixer for 1 hr at 122oC. The optical micrographs(POM) of a pure FLC and QDs - FLC composite were taken using a polarizing microscope under crossed polarizer conditions in a planar aligned cell as shown in figures 13(a), (b) and (c). It is clearly observable from the POM images of the pure and QD - FLC composite that the surface morphology or the alignment of the pure FLC has been significantly changed after the dispersion of QDs. The presence of QDs significantly changes the surface property (molecular alignment) and leads to subsequent changes in the PL properties of QDs - FLC composites.

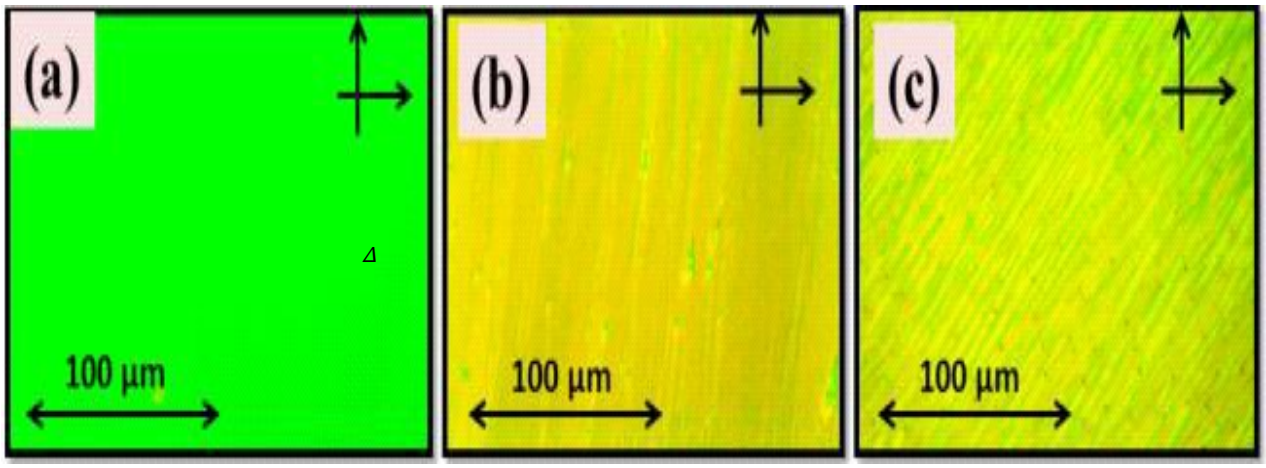


Figure 13. Polarizing optical micrographs (POMs) of planar aligned samples of (a) pure (b) Mix.1 and (c) Mix.2 taken at 35°C under crossed polarizer conditions.

The PL spectra of all the samples were recorded. The PL spectra of FLC composite at a 350nm excitation wavelength is depicted in figure 14(a). It can be seen that the FLC material emits strongly with a maximum at ~394nm. Emission spectra are broad in nature and composed of three submerged components, as presented in figure 14(b).

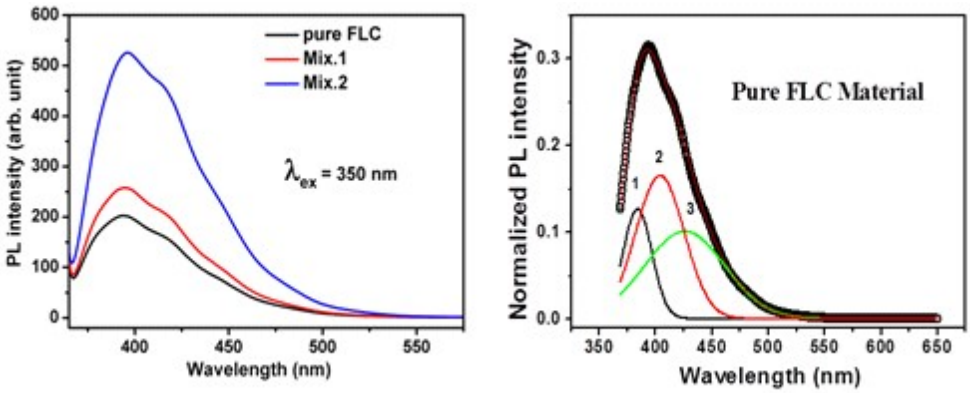


Figure 14. (a) Photoluminescence spectra of FLC material and QDs - FLC composites. (b) The de-convoluted PL spectra of FLC material.

PL emission spectra of QDs - FLC composite depict a substantial increase in the intensity of PL emission of an FLC material after the dispersion of QDs. The emission bands of the FLC material was modified and shifted by the dispersion of the ZnS quantum dot. The PL emission for Mix.1 and for Mix.2 was found to be centred at 395nm and 396nm, respectively. The PL intensity for the QD dispersed FLC has been enhanced by almost threefold for Mix.2. Such a large enhancement can be attributed to high molecular ordering due to the presence of a quantum dot. It means that a high dipole moment of QDs [33] leads to additional ordering of an FLC molecule, which subsequently affects the surface morphology of the composite system as discussed earlier in the manuscript. So it can be concluded that the emission from the QDs is combining constructively with the emission from the highly scattering phase of the FLC material due to the high ordering of an FLC molecule in the composite system [34]. Present study provides a better understanding of the optical properties of QDs - FLC composites for the development of display technology.

3 Conclusion:

In summary, they have developed a rapid, modular synthesis of new side-attaching calamitic promesogenic ligands. Their attachment to quantum dots and subsequent self-assembly in a liquid crystal host demonstrates the broad applicability of nematic templating. The use of these liquid crystalline molecules to functionalize quantum dots was motivated by the drive to develop hybrid materials with added functionalities. In the case of QDs, this modification allows better dispersion in LQ hosts [10], templated assembly into three-dimensional architectures and possibly novel photonics applications.

References:

1. A J Al-Alwani1, A S Chumakov, M S Albermani, O A Shinkarenko, N N Begletsova, A M Vostrikova, I A Gorbachev, S B Venig, E G Glukhovskoy, IOP Conf. Series: Journal of Physics: Conf. Series 917 (2017) 032026 doi :10.1088/1742-6596/917/3/032026 .
2. Andrea L. Rodarte, Zachary S. Nuno, Blessing H. Cao, Ronald J. Pandolfi, Makiko T. Quint, Sayantani Ghosh, Jason E. Hein,and Linda S. Hirst CHEMPHYSCHEM DOI: 10.1002/cphc.201301007.
3. Mingxuan Cao, Yating Zhang, Xiaoxian Song, Yongli Che, Haiting Zhan2, Chao Yan, Haitao Dai, Guang Liu, Guizhong Zhang and Jianquan Yao,Nanotechnology 27 (2016) 26LT01 (5pp) doi:10.1088/0957-4484/27/26/26LT01 .
4. A.V. Elopov, V.B. Zaytsev, D.M. Zhigunov, G.A. Shandryuk, A.A. Ezhov, A.S. Merekalov, L.A. Golovan,ISSN 1062-8738, Bulletin of the Russian Academy of Sciences: Physics, 2019, Vol. 83, No. 1, pp. 32-36. © Allerton Press, Inc., 2019. Russian Text © 2019, published in Izvestiya Rossiiskoi Akademii Nauk, Seriya Fizicheskaya, 2019, Vol. 83, No. 1, pp. 41-45. DOI: 10.3103/S1062873819010064.
5. Tripti Vimal, Dharmendra P. Singh, Kaushlendra Agrahari, Atul Srivastava, and Rajiv Manohar doi: 10.4302/plp.2016.1.09 PHOTONICS LETTERS OF POLAND, VOL. 8 (1), 23-25 (2016) .
6. Pankaj Kumar Tripathi , Bipin Joshi , Shri Singh Optical Materials 69 (2017) 61e66.
7. Javad Mirzaei,a Mitya Reznikovb and Torsten Hegmann Journal of material chemistry DOI: 10.1039/c2jm33274d 2012.
8. Stamatoiu, J. Mirzaei, X. Feng and T. Hegmann, Top. Curr. Chem., 2012, 318, 331-393.

9. U. Shivakumar, J. Mirzaei, X. Feng, A. Sharma, P. Moreira and T. Hegmann, Liq. Cryst., 2011, 38, 1495-1514.
10. T. Hegmann, H. Qi and V. M. Marx, J. Inorg. Organomet. Polym.Mater., 2007, 17, 483-508.
11. H. Qi and T. Hegmann, J. Mater. Chem., 2008, 18, 3288-3294.
12. J. P. F. Lagerwall and G. Scalia, Curr. Appl. Phys., 2012, 1-26.
13. H. K. Bisoyi and S. Kumar, Chem. Soc. Rev., 2011, 40, 306-319.
14. J. Ouyang, M. B. Zaman, F. J. Yan, D. Johnston, G. Li, X. Wu, D. Leek, C. I. Ratcliffe, J. A. Ripmeester and K. Yu, J. Phys. Chem. C, 2008, 112, 13805-13811.
15. K. Yu, J. Ouyang, M. B. Zaman, D. Johnston, F. J. Yan, G. Li, C. I. Ratcliffe, D. M. Leek, X. H. Wu, J. Stupak, Z. Jakubek and D. Whitfiel, J. Phys. Chem. C, 2009, 113, 3390-3401.
16. Reports on Progress in Physics Gautam Singh a, Michael Fisch b, and Satyendra Kumar a Published 18 April 2016 o © 2016 IOP Publishing Ltd Reports on Progress in Physics, Volume 79, Number 5
17. Green, M., Semiconductor Quantum Dots: Organometallic and Inorganic Synthesis, Cambridge: Royal Society of Chemistry, 2014.
18. Gorbachev I A, Goryacheva I Y, Brezesinski G, Gluhovskoy E G. 2016 Proc. of SPIE 9917 99171J-1.
19. Singha G, Fischb M R, Kumar S 2016 Liquid Crystals 1-9.
20. Chen C-T, Liu C-C, Wang C-H, Chen C-W, Chen Y-F 2011 Appl. Phys. Lett. 98 261918
21. M. S. karabot, I. Mus evic, Soft Matter 2010, 6, 5476- 5481.
22. A. L. Rodarte, C. Grey, L. S. Hirst, S. Ghosh, Phys. Rev. B 2012, 85, 035430.
23. Y. K. Verma, R. H. Inman, C. G. L. Ferri, H. Mirafzal, S. N. Ghosh, D. F. Kelley, L. S. Hirst, W. C. Chin, S. Ghosh, Phys. Rev. B 2010, 82, 165428.
24. A. L. Rodarte, G. Shcherbatyuk, L. Shcherbatyuk, L. S. Hirst, S. Ghosh, RSC Adv. 2012, 2, 12759-12763.
25. E. Mohagheghpour, M. Rabiee, F. Moztarzadeh, M. Tahriri, J. Ceramic Proc. Research 11(2), 144 (2010).
26. Tselikov, G.I., Timoshenko, V.Yu., Plenge, J., Ruhl, E., Shatalova, A.M., Shandryuk, G.A., Merekalov, A.S., and Tal'roze, R.V., Semiconductors, 2013, vol. 47, p. 647.
27. Tselikov, G.I., Dorofeev, S.G., Tananaev, P.N., and Timoshenko, V.Yu., Semiconductors, 2011, vol. 45, p. 1173.
28. Rodarte A L, Nuno Z S, Cao B H, Pandolfi R J, Quint M T, Ghosh S, Hein J E and Hirst L S 2014 Chem. Phys. Chem 15 1413.
29. Prodanov M F et al 2013 Langmuir 29 9301.
30. Mirzaei J, Reznikov M and Hegmann T 2012 J. Mater. Chem. 22 22350.
31. Cheng M C, Chu C C, Su Y C, Chang W T, Hsiao V K S, Yong K T, Law W C and Prased P N 2012 IEEE Photonics J. 4 19.
32. Cavalieri S, Wiersma D S, Yaroshchuk O and Gottardo S 2004 Phys. Rev. Lett. 93 263901
33. I.A. Ostapenko, G. Honig, C. Kindel, S. Rodt, A.Strittmatter, A. Hoffmann, D. Bimberg, Appl. Phys. Lett. 97, 063103 (2010).
34. A. Kumar , J. Prakash, A.D. Deshmukh , D. Haranath, P. Silotia, A.M. Biradar, Appl. Phys. Lett. 100, 134101 (2012).

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Role of TNF-α (G308A) gene polymorphism with essential Hypertension in Vindhyan Population

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Abstract

Hypertension is one of the major risk factors for cardiovascular disease morbidity and mortality. In order to reduce events related to cardiovascular disease, control of hypertension is very important. The clinical phenotypes of hypertension are known to be affected by both lifestyle and genetic factors. Genetic approaches in humans encompass molecular investigations of rare inherited syndromes of human hypertension, and direct analysis of essential hypertension in humans.There is an accumulating body of evidence indicating that alterations of the immune system are involved in the cascade of events leading to essential hypertension (EH). Concentration of TNF-α level in hypertension patient (case) and healthy population (control) is showing elevated level during infection and it was statistically significant associated as P<0.0001*** . Overall distribution of TNF-α (G308A) genotypes was significantly different in healthy control group as compared to disease group ($\chi 2$=13.01, P=0.0015**). HC group showed a decrease of mutant 'AA' genotype as compared to Patients of Essential hypertension (1.11% vs. 4.37%). Similarly, wild type 'GG' genotype was present in significantly high frequency in HC as compared to Essential hypertension patients group (72.22% vs. 54.37%).

Keywords: Essential hypertension, TNF-α (G308A), Allele frequency, RFLP, Blood pressure.

INTRODUCTION:

Essential hypertension is a chronic pathological state that afflicts about a third of the entire human population [1]. It is a major risk factor for premature cardiovascular disease, coronary and peripheral atherosclerosis, cardiac hypertrophy, heart failure, ischemic stroke, intracerebral hemorrhage and chronic and end-stage renal disease. More than ninety percent of the cases of hypertension do not have an identifiable cause and, therefore, are classified as essential or primary hypertension. Essential hypertension is thought to originate from the interaction between genetic and environmental factors. Finding a new gene associated with EH will help clarify the pathogenesis of EH and provide a new therapeutic strategy. The pathogenesis of EH is not limited to cardiovascular areas and is also related to immunology as well as heredity [1]. Inflammation plays a key role in the development of such cardiovascular diseases as atherosclerosis, diabetes, and so on [2]. The association of inflammation with EH has received increased attention for the past few years. Tumor necrosis factor-alpha (TNFα), the inflammation promoter, is secreted primarily by mononuclear phagocyte cells. TNFα induces endothelial cells to secrete vasoactive substances via the autocrine or paracrine pattern, which leads to vasorelaxation or vasoconstriction, and ultimately, to the regulation of blood pressure (BP) [3]. The TNFα gene is located in the major histocompatibility complex III region on chromosome 6p21.3. Recent research has revealed that TNFα gene polymorphisms are mostly focused on the probable influence of the promoter district on the expression of the TNFα gene. The TNFα gene polymorphism is also involved in infectious diseases, metabolic syndrome, stroke, hyperuricemia, and so on [1-4].

Essential hypertension is a common disorder affected by environmental and polygenic factors. In order to determine the pathogenesis of hypertension and to device a novel treatment method, it is essential to find new genes associated with hypertension. In addition to heredity and immunology, cardiovascular factors can be highly relevant to the pathogenesis of hypertension. Coronary atherosclerotic heart disease (CHD) characterizes as myocardial ischemia and hypoxia which arises from coronary atherosclerosis.[1] It is a worldwide medical problem and is still one of the leading causes of death in developed and developing countries.[2] At present, the occurrence and development of CHD is generally considered as a chronic inflammatory process characterized by highly specific cytokine response.[3] The regulation network formed by various proinflammatory and anti-inflammatory factors plays an immunomodulatory role in atherosclerosis.[4] Various proteins, cytokines, and adhesion molecules are involved in the development of coronary angiogenesis.[5] Among

them, TNF-α and IL-6 have significant effects on the development of coronary heart disease.[6,7] It has been showed that both of them are capable to damage endothelium function and act on the plaque of the vessel wall, accelerating the rupture of the plaque and triggering the clinical coronary events.[8] As a complex disease, CHD results from the interaction between genetic and environmental factors.[9] Recent studies have suggested that the basic level and biological activity of TNF-α and IL-6 can be influenced by gene polymorphism, which may increase the risk of CHD[10,11] C863A of TNF-α and C174G of IL-6 are the mostly investigated but the results remain inconsistent. The TNF-α C863A gene polymorphism was associated with the pathogenesis of CHD through case-control study. The studies on IL- 6 gene polymorphism and risk of CHD are also inconsistent, similar to that research status of TNF-α [5-9].

MATERIAL AND METHODS

Study population:

The study population consisted of 340 unrelated subjects comprising of 160 Essential Hypertension patients and 180 ethnically matched controls of central Indian population were included in this study. In this region Hindu, Muslim and some Sikh peoples are mainly living but most people's belong to Hindu religion in this region.

Inclusion and Exclusion criteria for Cases:

Cases included consecutive patients who attended the Department of Medicine, Shyam Shah Medical College and Sanjay Gandhi Memorial Hospital, Rewa, Ayurveda Medical College, Rewa, Ranbaxy pathology Regional collection centre Rewa, District hospital Satna, Shahdol, Sidhi. Hypertension was diagnosed in accordance with World Health Organization (WHO Expert committee 2003) criteria.

Inclusion and Exclusion criteria for Controls:

Control group composed of non-diabetic healthy individuals that were collected during "Diabetes Awareness Camps" organized in urban regions in and around SSMC Rewa and many volunteers were also included to collect control sample. The control subjects were recruited from the regions that from homogenous cluster in Vindhyan region India in accordance with a recent report of genetic landscape of the people of India. (Indian Genome Variation Consortium 2008)

Blood collection and plasma/serum separation:

Venous blood samples were obtained from the subjects after 12 hours of overnight fasting in vacutainers with and without appropriate anti-coagulants. Immediately, plasma and serum from the respective vacutainers were separated by centrifuging the tubes at 1000 rpm for 10 min. at 4^0C

ELISA Analysis:

Biochemical parameters related to Essential Hypertension is immunological cytokine TNF-α selected. Antigen-antibody reaction based ELISA kit (Diaclone, cat.no. 950090096) for detection of human TNF-α in isolated blood serum were provide statistical data to stabilize association to Essential hypertension.

Molecular Laboratory Analysis:

Method for DNA isolation:

Genomic DNA was extracted from whole blood by the modification of salting out procedure described by Miller and coworkers (Miller et al. 1988). Frozen blood sample was thawed at room temperature. 0.5 ml. of whole blood sample was suspended in 1.0 ml. of lysis buffer (0.32 M Sucrose, 1 mM Mgcl2, 12 mM Tris and 1% Triton-X-100) in a 1.5 ml. microcentrifuge tubes. This mixture was mixed gently by inverting the tube upside down for 1 min. The mixture was than allowed to stand for 10 min. at room temperature to ensure proper lysis of cells. The mixture was centrifuged at 11,000 rpm for 5 min. at 4^0C to pellet the nuclei. The supernatant was discarded carefully in a jar containing disinfectant, as pellet formed is loosely adhered to the bottom of centrifuge tube. The pellet was resuspended in 0.2 ml. of lysis buffer and recentrifuge at 11,000 rpm for 5 min. The pellet was than dissolved in 0.2 ml. of deionized autoclaved water and mixed thoroughly on vortexer. The mixture was centrifuged at 14,000 rpm for 1 min. at 4?C. Supernatant was discarded to gain an intact pellet. To the above pellet, 80 µl. of proteinase K buffer (0.375 M Nacl, 0.12 M EDTA, pH 8.0) and 10 µl. of 10% SDS (10% w/v SDS, pH 7.2) was added. Mixture was well frothed with the help of micro tip to allow proper lysis of pelleted nuclei. After digestion was complete, 100 µl. of saturated cold 5M Nacl was added and shaken vigorously for 15 sec. To the above mixture 0.2 ml. of deionized, autoclaved water and 0.4 ml. of phenol-chloroform (4:1 v/v) was added to remove most of the non nucleic acid organic molecules. Microcentrifuge tube was inverted upside down until the solution turned milky. Phases were separated by centrifuging the above mixture at 12,000 rpm for 10 min. at 4^0C. Aqueous (top) layer was saved and transferred in another microcentrifuge tube. Transferring of any interface layer was avoided. To the aqueous layer, 1 ml. chilled absolute ethanol was added and the tube was inverted several times until the DNA precipitated. DNA precipitates like thread. This was centrifuged at 14,000 rpm for 4 min. at 4^0C to pellet the DNA thread. Supernatant was discarded. The pellet was washed twice with 1 ml. of 70% alcohol. The mixture was again centrifuged at 14,000 rpm for 1 min. 4^0C.

Supernatant was discarded and pellet was air dried for 10-20 min. The pelleted DNA was rehydrated in 100-200 µl. of TE buffer pH 7.4 (10 mM Tris-HCL pH 7.4, 1mM EDTA, pH 8.0). DNA was allowed to dissolve overnight at 37^0C before quantization.

Determination of quality and quantity of isolated DNA:

The isolated DNA is to be used for PCR based study. Therefore its suitability for PCR along with its size heterogeneity is among the most important criterion for purity. As a matter of general practice all DNA preparations were tested for quality and quantity measures, as described in the following paragraphs.

Quantitation by UV spectrophotometry:

The isolated genomic DNAs were then tested for purity by measuring their absorbance values at 230 nm, 260 nm, 280 nm and 300 nm using a UV visible spectrophotometer (Systronic, India). A DNA preparation was considered to be good if it had A 260 nm / A 280 nm ratio as approximately 1.8 and A 300 nm was 0.1 or lesser. The absorbance at 260 nm was used to calculate the amount of DNA, using the relationship that double stranded DNA at 50µg/ml concentration has an absorbance= 1.0 at 260 nm.

Agarose Gel Electrophoresis:

Gel electrophoresis of the genomic DNAs was carried out for qualitative estimation of samples prepared. A good DNA preparation appears as single band. A horizontal agarose slab gel electrophoresis apparatus (Bangalore Genei, Bangaore, India) was used. In brief, 4-5 µl of each genomic DNA was loaded on 0.8 agarose (0.8 % w/v, Sigma) containing ethidium bromide solution (0.5 µg/ml) and electrophoresis was done at 80 V in 1x TAE buffer (40 mM Tris, 20 mM acetic acid, 1 mM EDTA). Lambda DNA EcoRI / Hind I double digest (Bangalore Genei, Bangalore, India) was used as molecular weight marker after completion of electrophoresis, the DNA bands were visualized and photographed using an UV transilluminator (312 nm) and gel documentation system (Vilber Lourmate, Cedex 1, France) respectively.

Polymorphism screening:

In general, the genomic DNA extracted from peripheral blood of healthy individuals and diseased individuals was subjected to PCR followed by restriction digestion and electrophoresis to genotype both the groups for relevant gene of interest. All the PCRs were carried out in a PTC 200 thermal cycler (MJ Research Inc. USA). PCR is a rapid, inexpensive and simple mean of producing relatively large copy number of DNA molecules from the small amounts of source DNA material, even when the source DNA is of relatively poor quality. Due to the extreme sensitivity, precautions were taken against contamination of the reaction mixture with the trace amounts of DNA, which could serve as an unwanted template. Appropriate negative control was included in each PCR run carried out for each gene, to monitor this contamination of PCR mix to avoid any false positive results. The negative control used for PCR contained whole PCR reaction mix except target DNA which was replaced by HPLC purified water free of RNase, DNase, and any contamination from any other source resembling the gene sequence.

Subsequently restriction enzyme digestion was performed by incubating the double stranded DNA with appropriate amount of restriction enzyme, in its respective buffer as recommended by the supplier and at optimal temperature for that specific enzyme. A typical digestion includes one unit of enzyme per microgram of starting DNA. One enzyme unit is usually defined as the amount of enzyme needed to completely digest one microgram of double stranded DNA in one hour at the appropriate temperature. Their biochemical activity of the restriction enzyme is the hydrolysis of phosphodiester backbone at specific sites in a DNA sequence. Precaution was taken to avoid star activity of restriction enzymes. When DNA is digested with certain restriction enzymes under non-standard conditions, cleavage can occur at sites different from the normal recognition sequence. Such aberrant cutting is called "star activity" which can be due to high pH (>8.0) or low ionic strength, extremely high concentration of enzyme (>100 U/µg of DNA) and presence of organic solvents in the reaction (e.g. ethanol, DMSO). The PCR and restriction digestion conditions were optimized for specific locus of relevant segment of the gene to be studied. The PCR products as well as the digested products were separated on either agarose gel or polyacrylamide gel depending on their size. Gels were stained with ethidium bromide solution (0.5µg/ml) and subsequently visualized and photographed under UV transilluminator

Detection of TNF-α (G308A) Polymorphism:

The tumor necrosis factor-alpha (TNF-α) gene may play an important role in coronary heart disease and hypertension. Essential hypertension is associated with the genetic mutations in TNF-α (G308A) gene, SNP rs1800629, generate tow allele G (wild type) and A (Mutated).

PCR Primer: The oligonucleotides sequences (primers) used were those described by K Jamil (Jamil K, et. al. 2016).

Forward primer- 5`- AGGCAATAGGTTTTGAGGGCCAT-3`
Reverse primer- 5`- TCCTCCCTGCTCCGATTCCG -3`

PCR Mix:

The PCR was carried out in a final volume of 25 µl, containing 100 ng of genomic DNA(4-5 µl), 2.5 µl of 10X Taq polymerase buffer (10 mM Tris HCl pH 8.8, 50 mM KCl, 1.5 mM MgCl2, 0.01% gelatin, 0.005% Tween-20, 0.005% NP-40; final concentration 1X; Genetix Biotech Asia Pvt. Ltd.,India), 1 µl of 10 mM dNTPs (Banglore Genei, Bangalore, India), 1 µl of 25 pmol/µl of forward and reverse primers specific for and 1µl of unit of 1U/ µl Red Taq DNA polymerase (Bangalre genei).

PCR Thermal Program:

After an initial denaturation of 5 min at 94^{0}C, the samples were subjected to 35 cycles at 94^{0}C for 1 min, at 55^{0}C for 40 s, and 72^{0}C for 40 s, with a final extension of 10 min at 72^{0}C in a thermal cycler. A 100bp ladder with amplified product has been run under 1% agarose gel electrophoresis. 107bp product will be generated after PCR.

Restriction Digestion by MspI:

Genetic polymorphism of TNF-α (G308A) gene at SNP rs1800629 was indicated two allele G and A. The PCR product was 107bp digested in to two fragments 87bp and 20bp. The PCR products when digested by restriction enzyme MspI produces allele A. The TNF-α (G308A) gene generates three genotype of GG, GA and AA where G was wild allele and A was rare mutant allele. A allele having restriction sit for enzyme MspI and give two fragments 87bp and 20bp.

Statistical Analysis of Genotype :

Statistical analysis was done by comparing the distribution of genotype frequencies, allele frequencies and carriage rates of all the four polymorphism in diseased and control group. Disease group included Diabetic patients whereas control group included all healthy controls (HC) enrolled in the study. The proportions of different genotypes for a gene in a population are known as genotype frequencies. The proportion of genotype in a sample will be the ratio of the number of individuals having that genotype to the total number of individuals in the sample. The proportions of different alleles for a gene present in a population are known as allele frequencies. The proportion of an allele in a sample will be the ratio of number of occurrences of the investigated allele in the population to the total number of alleles. The carriage rate was calculated as the number of individuals carrying at least one copy of the test allele divided by the total number of individuals. Data was analyzed using Microsoft Excel 2002, Microsoft Corporation. Only the biochemical parameters, for difference between obese diabetic patients and the obese non-diabetic controls were assessed using the student's t test. Similarly the biochemical parameters between the normal weight patients and normal weight non-diabetic controls were also assessed. The P-values calculated using t test along with the mean (inter-quartile range) were presented. Statistical analyses were performed using statistical package, Prism 3.0, Prism 5.1 version.

RESULTS

ELISA Analysis of TNF-α cytokine

Tumor necrosis factor-α (TNF-α) is a pleiotropic cytokine that becomes elevated in chronic inflammatory states such as essential hypertension infection. Concentration of TNF-α level in hypertension patient (case) and healthy population (control) is depicted in table no.1, is showing elevated level during infection and it was statistically significant associated as P<0.0001*** . This is kit based ELISA result reveals elevated TNF-α level in hypertension infection. In figure no. 4.3, two columns ELISA analysis having four standards A, B, C, D containing 25, 50, 100, 200 Pg/ml concentration respectively read absorbance at 450 nm. G for Patient (Case) and H for Healthy (control) showing differences in TNF-α level as 23.97 Pg/ml and 11.82 Pg/ml respectively.

Detection of Genetic Polymorphism in TNF-α (G308A) gene:

The nucleotide position G308A polymorphism in TNF-α gene create restriction site for HinII. The PCR products when digested by restriction enzyme and wild type allele 107 bp segment which were generated by PCR but the mutant allele shows 87 and 20 bp segments. The product sizes are Wild type homozygote, 107 bp; mutant G308A homozygote, 87 and 20 bp; and heterozygote, 107, 87, and 20 bp respectively

(Depicted in figure no. 4.3.)

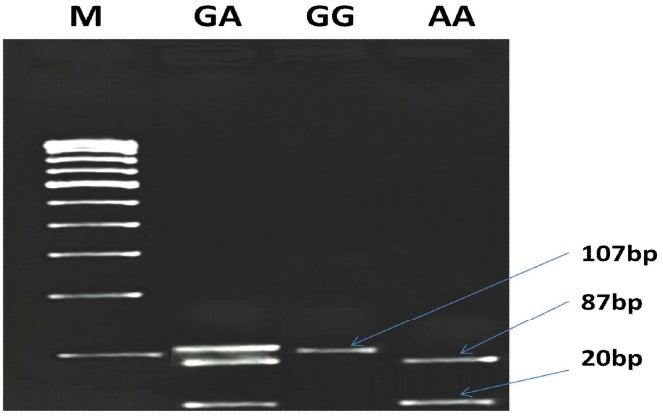


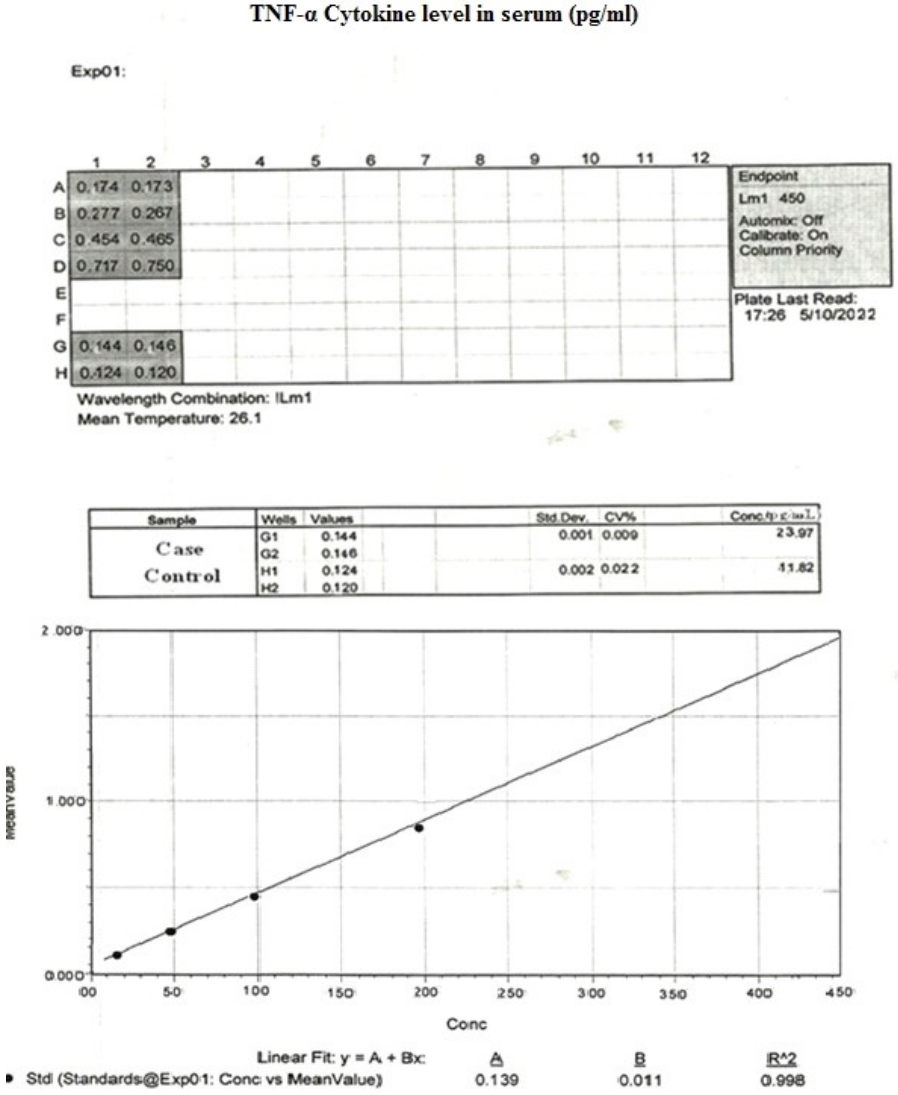
Figure No.-1: Representative gel picture of TNF-α (G308A) polymorphism. Lane M represents 50 bp molecular marker, Lane GG Wild type genotype, Lane GA heterozygous genotype and Lane AA variant genotype.

TABLE No-1

Comparison of Biochemical Factor between Essential hypertension Cases and Healthy Controls:

Biochemical Factor	*Cases(160)*	*Controls(180)*	*P-value*
TNF-α Cytokine Level in serum (pg/mL)	23.97 ± 9.52	11.82 ± 6.41	(P<0.0001)***

(*Denotes level of significant change between malarial cases and healthy controls.)



Graph No.-1; TNF-α Cytokine Level in both case and control. Straight line graph is showing concentration change accordance to absorbance.

The distribution of polymorphic genotype was strongly under HWE. The observed genotype frequencies, allele frequencies and carriage rates for TNF-α (G308A) polymorphism are depicted in table 4.10 and table 4.11 and graph no. 4.9, 4.10, 4.11. Overall distribution of TNF-α (G308A) genotypes was significantly different in healthy control group as compared to disease group (χ^2=13.01, P=0.0015**). HC group showed a decrease of mutant 'AA' genotype as compared to Patients of Essential hypertension (1.11% vs. 4.37%). Similarly, wild type 'GG' genotype was present in significantly high frequency in HC as compared to Essential hypertension patients group (72.22% vs. 54.37%). An odds ratio of 0.4584 in Essential hypertension group respectively for 'GG' genotype indicated a protective effect of this type genotype in our population whereas an odds ratio of 4.072

for Mutant TT Essential hypertension patients group respectively indicated a positive association of this wild type genotype with the disease, heterozygous is also significantly different but may be not protective because of odds ratio of 0.7094.

Overall allele 'T' was found to be in significantly low frequency in disease group as compared to HC group whereas allele 'G' was present in significantly high frequency in the healthy control group (χ^2 =12.07 P= 0.0005***). Overall G allele shows an odds ratio of 0.5065 which indicates its protective association. Carriage rate of allele 'G' was high in HC group whereas carriage rate of allele 'T' was high in disease group (χ^2 =6.180 P=0.0129*) but the values were not significant. .The pattern of genotype and allele distribution in disease and control group suggested a significant association of TNF-α (G308A) wild type allele 'G' carriage (carriage of 'GG') in Susceptibility to Essential hypertension and not show the protective effect.

TABLE No-2

Frequency distribution and association of Genotype, allele frequency and carriage rate of TNF-α (G308A) gene polymorphism in population of Vindhyan region using Chi Square Test

TNF-α (G308A) GENE	CASE N= 160 N	%	CONTROL N=180 N	%	CHI SQUARE VALUE χ^2 (P Value)
Genotype					
GG	87	54.37	130	72.22	
GA	66	41.25	48	26.66	13.01 (0.0015**)
AA	7	4.37	2	1.11	
Allele					
G	240	75.00	308	85.55	
A	80	25.00	52	14.44	12.07 (0.0005***)
Carriage Rate					
G	153	67.69	178	78.07	
A	73	32.30	50	21.92	6.180 (0.0129*)

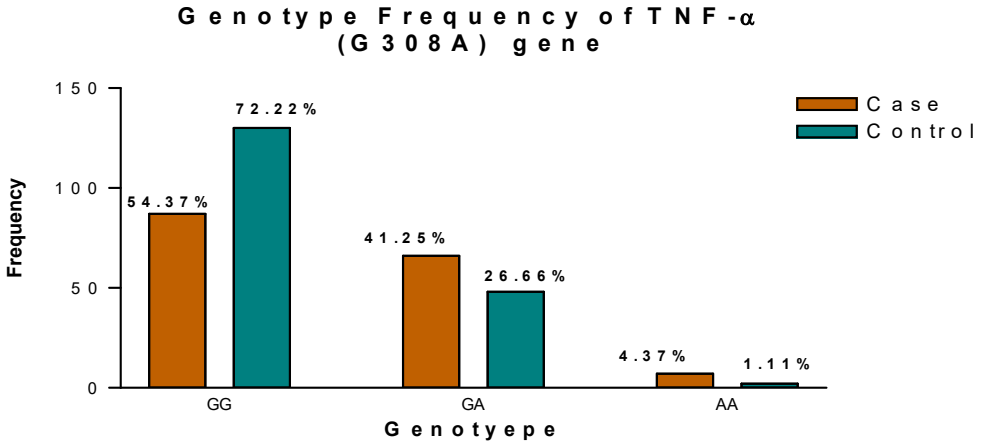
(- denotes the level of significant association between case and control.)*
(N – Number of individuals in study group.)
(% - Genotype allele frequency and carriage rate expressed in percentage.)

TABLE No-3

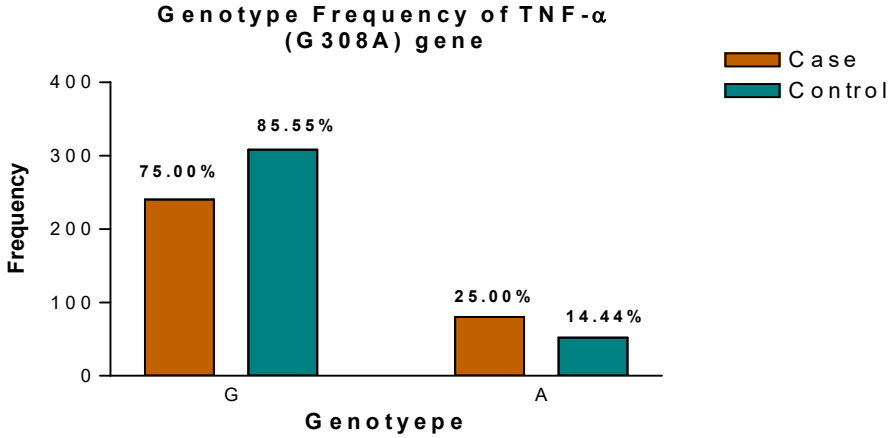
Fisher Exact Test values of TNF-α (G308A) gene polymorphism

TNF-α (G308A) GENE	CASE N= 160 N	%	CONTROL N=180 N	%	P Value	Odds Ratio (95% confidence interval)
Genotype						
GG	87	54.37	130	72.22	0.0007***	0.4584 (0.2920 to 0.7195)
GA	66	41.25	48	26.66	0.0057**	1.931 (1.223 to 3.048)
AA	7	4.37	2	1.11	0.0894ns	4.072 (0.8332 to 19.90)
Allele						
G	240	75.00	308	85.55	0.0006***	0.5065 (0.3437 to 0.7465)
A	80	25.00	52	14.44		1.974 (1.340 to 2.910)
Carriage Rate						
G	153	67.69	178	78.07	0.0151*	0.5887 (0.3869 to 0.8958)
A	73	32.30	50	21.92		1.699 (1.116 to 2.585)

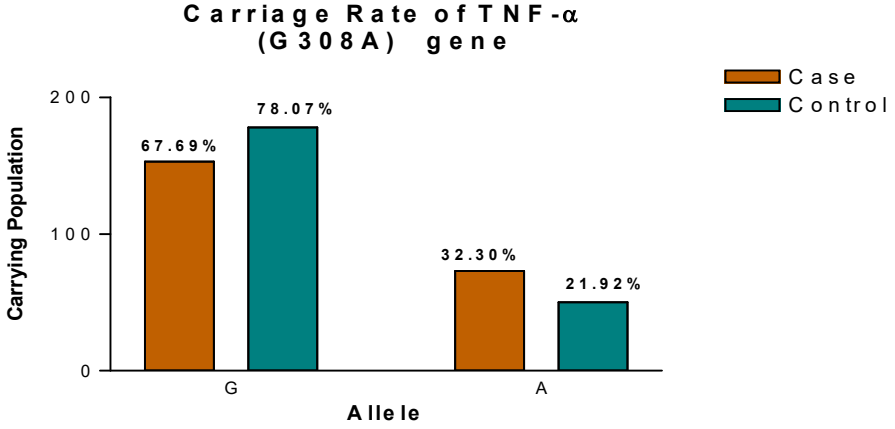
(- denotes the level of significant association between case and control.)*
(N – Number of individuals in study group.)
(% - Genotype allele frequency and carriage rate expressed in percentage.)



Graph No.-2: Genotype Frequency of TNF-α (G308A) gene



Graph No.-3: Allele Frequency of TNF-α (G308A) gene



Graph No.-4: Carriage rate of TNF-α (G308A) gene

DISCUSSION:

Tumor necrosis factor α (TNF-α) and interleukin 6 (IL-6) are proinflammatory cytokines and known to be involved in many pathological processes. However, the association between serum levels of TNF-α, IL-6, and pregnancy-induced hypertension (PIH) is unclear [12]. The aim of the present study was to determine the serum levels of TNF-α and IL-6 and to investigate their potential correlation with PIH [11]. The serum concentrations of TNF-α and IL-6 in pregnant women who developed PIH and normal pregnant women were measured. We found that the serum concentrations of TNF-α and IL-6 were significantly increased in the patients with PIH compared to the normal pregnant women. In addition, elevated TNF-α and IL-6 concentrations were associated with pathological complications [10,13]. Moreover, in a hypoxia-induced PIH mice model, animals from the PIH group demonstrated higher TNF-α and IL-6 levels when compared to control, and serum TNF-α and IL-6 levels were positively correlated with right ventricular systolic blood pressure [10-14].

Our study on TNF-α associated with hypertension. Thus Tumor necrosis factor-α (TNF-α) is a also pleiotropic cytokine that becomes elevated in chronic inflammatory states such as essential hypertension infection. Concentration of TNF-α level in hypertension patient (case) and healthy population (control) is showing elevated level during infection and it was statistically significant associated as P<0.0001***. In case of TNF-α, two columns ELISA analysis also having four standards A, B, C, D containing 25, 50, 100, 200 Pg/ml concentration respectively read absorbance at 450 nm. G for Patient (Case) and H for Healthy (control) showing differences in TNF-α level as 23.97 Pg/ml and 11.82 Pg/ml respectively.

The tumor necrosis factor-alpha (TNFα) G308A gene polymorphism has been implicated in susceptibility to essential hypertension (EH), but study results are still controversial. The present meta-analysis is performed to investigate the relationship between the TNFα G308A gene polymorphism and EH [16,17]. Electronic databases were searched and seven separate studies on the association of the TNF a G308A gene polymorphism with EH were analyzed. The meta-analysis involved 1092 EH patients and 1152 controls. The pooled odds ratios (ORs) and their corresponding 95% confidence interval (CI) were calculated by a fixed or random effect model. A significant relationship between the TNFα G308A gene polymorphism and EH was found in an allelic genetic model [15,18]. Genomic DNA was extracted; PCR-RFLP was performed using TNF-α primers specific to detect the presence of SNPs. The PCR-RFLP studies showed that among the Snp238G/A types the GG genotype was 87%, GA genotype was 12% and AA genotype was 1%. Almost a similar pattern of results was obtained with TNF-α Snp308G/A polymorphism. The results obtained were evaluated statistically to determine the significance [15-19].

Our study on TNF-α gene suggested that the nucleotide position G308A polymorphism in TNF-α gene create restriction site for HinII. The PCR products when digested by restriction enzyme and wild type allele 107 bp segment which were generated by PCR but the mutant allele shows 87 and 20 bp segments. The product sizes are Wild type homozygote, 107 bp; mutant G308A homozygote, 87 and 20 bp; and heterozygote, 107, 87, and 20 bp respectively. The distribution of polymorphic genotype was strongly under HWE. The observed genotype frequencies, allele frequencies and carriage rates for TNF-α (G308A) polymorphism are depicted in table 4.10 and table 4.11 and graph no. 4.9, 4.10, 4.11. Overall distribution of TNF-α (G308A) genotypes was significantly different in healthy control group as compared to disease group (χ^2=13.01, P=0.0015**). HC group showed a decrease of mutant 'AA' genotype as compared to Patients of Essential hypertension (1.11% vs. 4.37%). Similarly, wild type 'GG' genotype was present in significantly high frequency in HC as compared to Essential hypertension patients group (72.22% vs. 54.37%). An odds ratio of 0.4584 in Essential hypertension group respectively for 'GG' genotype indicated a protective effect of this type genotype in our population whereas an odds ratio of 4.072 for Mutant TT Essential hypertension patients group respectively indicated a positive association of this wild type genotype with the disease, heterozygous is also significantly different but may be not protective because of odds ratio of 0.7094. Overall allele 'T' was found to be in significantly low frequency in disease group as compared to HC group whereas allele 'G' was present in significantly high frequency in the healthy control group (χ^2 =12.07 P= 0.0005***). Overall G allele shows an odds ratio of 0.5065 which indicates its protective association. Carriage rate of allele 'G' was high in HC group whereas carriage rate of allele 'T' was high in disease group (χ^2 =6.180 P=0.0129*) but the values were not significant. .The pattern of genotype and allele distribution in disease and control group suggested a significant association of TNF-α (G308A) wild type allele 'G' carriage (carriage of 'GG') in Susceptibility to Essential hypertension and not show the protective effect.

The tumor necrosis factor-alpha (TNF-α) gene

may play an important role in coronary heart disease (CHD) and myocardial infarction (MI) risk. Recently, controversial results regarding the association of the G-308 A (rs1800629) polymorphism of the TNF-α gene with CHD/MI have been reported [21,23]. AA genotypes in the G-308 A (rs1800629) polymorphism of the TNF-α gene did not occur more frequently in CHD/MI patients than in controls; odds ratios (95% confidence intervals) were 1.743 (0.325 to 1.423) for CHD and 1.731 (0.442 to 1.526) for MI, after adjusting for conventional risk factors. Further stratification for age, gender, and other cardiovascular risk factors did not alter the prior negative findings [22]. Pooled meta-analysis of 23 studies also found no statistically significant associations between the TNF-α polymorphism and CHD/MI risk in the genetic additive, dominant, and recessive models [24]. Subgroup analyses showed no association between the TNF-α polymorphism and CHD/MI in Asian and Caucasian populations. Our study showed no association between the G-308 A (rs1800629) polymorphism of the TNF-α gene (presence of A allele) [20-25].

CONCLUSSION:

Our data revealed that association of G-308 A (rs1800629) polymorphism of the TNF-α gene with Essential hypertension. An association of TNF-α-308 polymorphism, a G/A transition at -308-bp position, which may alter promoter activity, with TNF-α expression in vitro, as well as plasma concentrations. An increased serum concentration of TNF-α is an independent predictor of Essential hypertension. The observed genotype frequencies, allele frequencies and carriage rates for TNF-α (G308A) polymorphism suggest distribution of TNF-α (G308A) genotypes was significantly different in healthy control group as compared to disease group (χ^2=13.01, P=0.0015**) in vidhyan population. HC group showed a decrease of mutant 'AA' genotype as compared to Patients of Essential hypertension (1.11% vs. 4.37%). Similarly, wild type 'GG' genotype was present in significantly high frequency in HC as compared to Essential hypertension patients group (72.22% vs. 54.37%). An odds ratio of 0.4584 in Essential hypertension group respectively for 'GG' genotype indicated a protective effect of this type genotype in our population whereas an odds ratio of 4.072 for Mutant TT Essential hypertension patients group respectively indicated a positive association of this wild type genotype with the disease, heterozygous is also significantly different but may be not protective because of odds ratio of 0.7094. Finally, we conclude that TNF-α, G-308 A (rs1800629) polymorphism was significantly associated with Essential hypertension in vindhyan population.

REFERENCES:

1. Kaur J. A comprehensive review on metabolic syndrome. Cardiol Res Pract. 2014;2014:943162.
2. McCracken E, Monaghan M, Sreenivasan S. Pathophysiology of the metabolic syndrome. Clin Dermatol. 2018;36(1):14-20.
3. Lau DC, Dhillon B, Yan H, Szmitko PE, Verma S. Adipokines: molecular links between obesity and atheroslcerosis. Am J Physiol Heart Circ Physiol. 2005;288(5):H2031-41.
4. Lee SC, Pu YB, Thomas GN, Lee ZS, Tomlinson B, Cockram CS, et al. Tumor necrosis factor alpha gene G-308A polymorphism in the metabolic syndrome. Metab Clin Exp. 2000;49(8):1021-4.
5. Srikanthan K, Feyh A, Visweshwar H, Shapiro JI, Sodhi K. Systematic review of metabolic syndrome biomarkers: a panel for early detection, management, and risk stratification in the west Virginian population. Int J Med Sci. 2016 ; 13(1):25-38.
6. Mohammadi M, Gozashti MH, Aghadavood M, Mehdizadeh MR, Hayatbakhsh MM. Clinical significance of serum IL-6 and TNF-α levels in patients withmetabolic syndrome. Rep BiochemMol Biol. 2017;6(1):74-9.
7. Maury E, Brichard SM. Adipokine dysregulation, adipose tissue inflammation and metabolic syndrome. Mol Cell Endocrinol. 2010;314(1):1-16.
8. Wilson AG, de Vries N, Pociot F, di Giovine FS, van der Putte LB, Duff GW. An allelic polymorphism within the human tumor necrosis factor alpha promoter region is strongly associated with HLA A1, B8, and DR3 alleles. J Exp Med. 1993;177(2):557-60.
9. Kabita S, Garg PR, Newmei MK, Saraswathy KN, Singh HSJJotPoCS. Tumor necrosis factor-alpha gene polymorphisms and complex disorders: A study among mendelian population with East Asian Ancestry 2019;5(1):35.
10. Gupta V, Gupta A, Jafar T, Gupta V, Agrawal S, Srivastava N, et al. Association of TNF-α promoter gene G-308A polymorphism with metabolic syndrome, insulin resistance, serum TNF-α and leptin levels in Indian adult women. Cytokine. 2012;57(1):32-6.
11. Arbab M, Tahir S, Niazi MK, Ishaq M, Hussain A, Siddique PM, et al. TNF-α genetic predisposition and higher expression of inflammatory pathway components in

Keratoconus. Invest Ophthalmol Vis Sci. 2017;58(9):3481-7.

12. Sookoian SC, González C, Pirola CJ.Meta-analysis on the G-308A tumor necrosis factor alpha gene variant and phenotypes associated with the metabolic syndrome. Obes Res. 2005;13(12):2122-31.
13. Rochlani Y, Pothineni NV, Kovelamudi S, Mehta JL. Metabolic syndrome: pathophysiology, management, and modulation by natural compounds. Ther Adv Cardiovasc Dis. 2017;11(8):215-25.
14. Brown AE, Walker M. Genetics of insulin resistance and the metabolic syndrome. Curr Cardiol Rep. 2016;18(8):75.
15. Banerjee M, Saxena M. Genetic polymorphisms of cytokine genes in type 2 diabetes mellitus. World J Diabetes. 2014;5(4):493-504.
16. Yee LJ, Tang J, Herrera J, Kaslow RA, van Leeuwen DJ. Tumor necrosis factor gene polymorphisms in patients with cirrhosis from chronic hepatitis C virus infection. Genes Immun 2000;1: 386-390.
17. Sookoian S, Garca SI, Gianotti TF, Dieuzeide G, Gonzalez CD, et al.; The G-308A promoter variant of the tumor necrosis factor-alpha gene is associated with hypertension in adolescents harboring the metabolic syndrome. Am J Hypertens;2005; 18: 1271-1275.
18. Liu ZW, Li JC, Li MX, Chen SQ; Study on TNFα-238G/A polymorphisnis in patients with cerebral infarction. Anat Res,2009, 31: 259-262.
19. Li CQ, Wang F, Wang YG; The Association of the TNF-α Gene of G- 308A Genotypes in Chinese hyperuricemia patients and cardiovascular risk factors. Molecular Cardiology of China, 2010, 10: 29-32.
20. Bogdan´ ski P, Kujawska-uczak M, acki J, Pupek-Musialik D, Evaluation of selected interleukins, tumor necrosis factor, insulin and leptin in obese patients with hypertension. Pol Merkur Lekarski;2003;15:347-349; discussion 349-51.
21. Mazor R, Itzhaki O, Sela S, Yagil Y, Cohen-Mazor M, et al. Tumor necrosis factor-alpha: a possible priming agent for the polymorphonuclear leukocyte-reduced nicotinamide-adenine dinucleotide phosphate oxidase in hypertension. Hypertension; 2010;55: 353-362.
22. Yoo CS, Hwang WJ, Hong SH, Lee HJ, Jeong HJ, et al. Relationship between iris constitution analysis and TNF-alpha gene polymorphism in hypertensives. Am J Chin Med;2007; 35: 621-629.
23. Guo LW, Wu HY, Huang YM, Li R, Wang KJ, et al. Correlation between tumor necrosis factor a and b gene polymorphisms and essential hypertension. Journal of Xinxiang Medical College; 2009;26: 352-354.
24. Peng CY, Zhou CL, He QZ; Association of TNF-a gene 2308G/A polymorphism with essential hypertension in Han racial origin in Hunan. Chin J Clin Pharmacol Ther;2011;16: 57-60.
25. Sookoian S, Garc?´a SI, Gianotti TF, Dieuzeide G, Gonza´lez CD, et al. The G-308A promoter variant of the tumor necrosis factor-alpha gene is associated with hypertension in adolescents harboring the metabolic syndrome. Am J Hypertens ;2005;18: 1271-1275.

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In Silico Analysis of Secondary Metabolites from Three Plants of Asteraceae Family as Potential Anticancer Agents Against Different Cancerous Proteins

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Abstract

Cancer is a significant threat to public health, despite decades of research. Plants have been used for medical purposes since the beginning of human history and are the basis of modern medicine. Many chemotherapeutic drugs for cancer treatment are molecules identified and isolated from plants or their synthetic derivatives. Our hypothesis is that whole plant extracts, which contain multiple molecules with antitumor activities, could be very effective in killing human cancer cells. This study evaluates metabolites from three Asteraceae plants-Parthenium hysterophorous L., Dittrichiaviscosa L., and Bidens pilosa L.-through in-silico methods to elucidate their anti-cancerous ability. A total of twenty-nine compounds from these plants were chosen to investigate their interaction ability with eight cancer-causing proteins: APC, β-catenin, BRCA1, BRCA2, EGFR, KRAS, CDK12, and PTEN. Molecular docking analysis was carried out using iGEMDOCK (2.1) to give insight into the affinity of these plant molecules for each protein. Out of all the metabolites, Axillaroside, Centaureidin, Taxifolin, Sakuranetin, Okanin, and Luteolin have shown a remarkable binding affinity for the proteins.

Keywords: in Silico Analysis, Secondary Metabolites, Asteraceae Family, Anticancer Agents.

1. Introduction

Plants have played a crucial role in ancient cultures for medicinal purposes, in addition to their use as food and spices, for over 5000 years (Dall'Eraet al 2020; Iqbal et al 2017). Historically, medicinal plants have been used to treat various diseases, including life-threatening ones (Iqbal et al 2017). It is estimated that 70-95% of the population in developing countries continue to rely on traditional medicines (Robinson and Zhang, 2011). Today, medicinal herbs are defined as plants containing valuable substances with therapeutic or beneficial effects in healing and preventing various ailments in humans and animals. Natural products such as plant extracts and dry powders of plant parts have been used as complementary treatments alongside conventional drugs (Li, 2002; Robinson and Zhang, 2011). Plant metabolites exhibit cytotoxic activity by inducing cell death or inhibiting cell division (Mazumderet al 2020). Various plant chemicals, including phenolics, terpenoids, and alkaloids, have been identified as having anti-carcinogenic properties. Cancer has become the leading cause of death globally in recent years (Shajiet al 2000; Danpanichkulet al 2023). In 2020, there were over 19.3 million new cancer cases and 10 million cancer-related deaths (Danpanichkulet al 2023). Genetic mutations or alterations in gene expression can disrupt cellular proliferation, leading to the development of cancer cells. Various proteins and receptors play essential roles in cancer cell formation and can be targeted to prevent cell lysis (Xu et al 2013). The BRCA1 and BRCA2 genes are linked to inherited breast cancer and are involved in the DNA damage repair system. Mutations in these genes have been associated with breast cancer (Kaur and Singh, 2024; Atroozet al 2023). β-catenin and APC proteins are part of the Wnt signaling pathway and are implicated in colorectal cancer development (Chen et al 2023). In mutated cells, β-catenin triggers abnormal transcription of genes capable of forming tumors. In normal cells, APC regulates β-catenin levels to control the transcription of developmental genes. However, in cells with mutated APC, β-catenin levels remain elevated without Wnt pathway activation, leading to continuous transcription of target genes and excessive cell proliferation. Similarly, mutations in growth factor receptors, such as EGFR and KRAS, are observed in lung cancer. EGFR is a surface receptor involved in cell survival and development (Oving and Clevers, 2002; Cui et al 2023), while KRAS is an oncogene downstream of EGFR that causes malignancy when mutated (Gevaertet al 2017). In prostate cancer, PTEN controls cell division and apoptotic cell death, and CDK12, another gene associated with prostate cancer, participates in the transcription of DNA repair genes and genome

stabilization (Greenwell & Rahman, 2015; Gandhi et al 2018; Dall'Eraet al 2020). This study uses molecular docking of secondary metabolites from three plants of the Asteraceae family Parthenium hysterophorus, Inula viscosa, and Bidens pilosa to analyze their anticancer properties against proteins involved in the development of lung, prostate, breast, and colorectal cancers.

2. Materials and methods

To carry out the study, we used biological databases like RCSB Protein Data Bank (PDB), Drug Bank, Pub Chem and National Center for Biotechnology Information (NCBI) for retrieving information about the structure of protein and ligand molecules. Protein homology modelling was done through SWISS-MODEL. Further, iGEMDOCK (version 2.1) was employed for protein-ligand docking and post-screening analysis. For converting SDF files to PDB format files online SMILES platform was used. Statistical analysis of the results was accomplished by SPSS (16.0.0) statistics software.

2.1. Preparation of target Protein

Protein structures were retrieved from the RCSB Protein Data Bank, and the corresponding FASTA sequences of selected proteins were obtained from the NCBI database using their PDB IDs. Homology structure modeling was conducted via SWISS-MODEL, with the experimental data derived from X-ray crystallography. The resulting protein structure models were saved in PDB format.Specifically, the proteins and their associations with various cancers are as follows: APC (PDB ID: 3NMX_C) is linked to colon cancer, β-catenin (PDB ID: 1T08_A) is also related to colon cancer, EGFR (PDB ID: P00533.2) is associated with lung cancer, KRAS (PDB ID: P01116.1) is connected to lung cancer, BRCA-1 (PDB ID: P38398.2) is linked to breast cancer, BRCA-2 (PDB ID: 1MJE_A) is also related to breast cancer, PTEN (PDB ID: P60484) is associated with prostate cancer, and CDK-12 (PDB ID: 6CKX_D) is linked to prostate cancer(Faux et al. 2021; Lee et al. 2018; Zhang et al. 2021; Wang et al. 2021; Metcalfe et al. 2021; Jamaspishvili et al. 2021; Rose et al. 2016;)

2.2 Preparation of ligand structure

To facilitate subsequent research endeavors, we accessed the three-dimensional (3D) molecular structures of selected compounds from the PubChem compound database. Initially retrieved in SDF format, these files were subsequently converted to PDB format, a crucial step for conducting docking studies. Utilizing the Pub Chem database proved invaluable, offering expansive access to chemical data associated with all the compounds identified in three related plants. The compounds from Parthenium hysterophorus include Caffeic acid (CID 689043), Charminarone (CID 11346474), Coronopilin (CID 257278), Ferulic acid (CID 445858), Fumaric acid (CID 444972), Hysterone D (CID 12115383), Parthenin (CID 442288), P-coumaric acid (CID 637542), Scopoletin (CID 5280460), and Tetraneurin A (CID 174868). From Bidens pilosa, the compounds include Apigenin (CID 5280443), Axillaroside (CID 44259807), Butein (CID 5281222), Campesterol (CID 173183), Centaureidin (CID 5315773), Centaurein (CID 5489090), Linoleic acid (CID 5280450), Luteolin (CID 5280445), Okanin (CID 5281294), and Sulfuretin (CID 5281295). Compounds from Inula viscosa include 3-Acetyl-7-O-methylaromadendrin (CID 15139424), Costic acid (CID 6451579), Ilicic acid (CID 11876195), Inuviscolide (CID 176489), Isocostic acid (CID 10922464), Quercetin (CID 5280343), Sakuranetin (CID 73571), Taxifolin (CID 439533), and Tomentosin (CID 155173). Additionally, the approved drug Capecitabine (CID 60953) was used as a standard in the study. The identification and conversion of these compounds were pivotal for the subsequent molecular docking studies, providing a robust foundation for further research into their potential biological activities(Marwat et al.2015; Rodríguez-Mesa et al. 2023; Zeouk et al. 2020).

2.2.1ADME toxicity assay

Comprehensive research was conducted with an emphasis on Absorption, Distribution, Metabolism, Excretion, and Toxicity (ADMET) in order to determine which of the five Ligands possessed the most potential pharmacologically active molecules. The Swiss ADMET analysis protocol was utilised in order to carry out the evaluation of the ADMET properties of the plant component. The investigations included a comprehensive range of important areas. Studies on the intestinal absorption of humans were carried out in order to determine the bioavailability of the substances when they were consumed directly through the mouth. In order to evaluate the potential adverse effects that the chemicals may have on the Central Nervous System (CNS), insights into blood-brain penetration were obtained. An investigation of the toxicity of AMES was carried out, which included tests for mutagenicity and carcinogenic characteristics. The mutagenicity assay, which was adapted from the Ames test, was able to make a prediction regarding the ability of the substances to make human cells undergo mutations. In the meantime, the carcinogenicity assay contributed to the understanding of the chemicals' ability to cause cancer in human cells that are normally functioning(Dulsat et al2023)

2.2.2 Drug likeness assay

To perform as a drug, a molecule should have physical properties that help in its easy absorption by the

body. An investigation of the drug-like properties of this chemical

Lipinski drug filters, which were developed by the Supercomputing Centre for Bioinformatics and Computational Biology (https://www.scfbio-iitd.res.in/utility/LipinskiFilters), were utilised in order to evaluate the drug-likeness features of each of the five compounds. The Lipinski rule of five is a useful tool for distinguishing between compounds that display drug-like features and those that do not exhibit such qualities. Observance of two or more of the following criteria is required for this classification to be considered valid: Less than 500 Dalton of molecular mass, high lipophilicity (reported as LogP less than 5), and high reactivity with water A molar refractivity that falls between 40 and 130 should be present, and there should be less than five hydrogen bond donors and fewer than ten hydrogen bond acceptors (LipinskiC. A.2004).

The molecular weight of molecule (MW) $\leq$ 500,
The octanol/water partition coefficient (iLOGP = A log P) $\leq$ 5,
The number of hydrogen bond donors (HBDs) $\leq$ 5,
The number of hydrogen bond acceptors (HBAs) $\leq$ 10.6, and,
The topological polar surface area (TPSA) < 40 Å2.

2.3 Molecular docking using iGEMDOCK (2.1)

To analyse their interactions, all protein molecules were docked against each of the ligand phytochemicals in iGEMDOCK (version 2.1). iGEMDOCK predicts the binding affinity of each protein-ligand docking with a total energy score based on log10. The lower the total energy of the compound higher the binding affinity as the reaction takes place more spontaneously. IGEMDOCK generates a series of interaction profiles for protein-compound interactions; Standard docking was chosen as the default setting with parameters of 200 population sizes, 70 generations and 2 solutions (Hsu et al. 2011).

3.0 Result and Discussion

Virtual screening techniques (e.g., molecular docking) have gained popularity for being low cost, fast and effective drug discovery method (Meng et al 2011). Molecular docking depends on molecular structure to predict stable binding configuration of two molecules with each other and thus demonstrates affinity between them (Sanghaniet al 2012). Plant molecules are known to have a vital role in folk medicine. Asteraceae plants have demonstrated previously for containing anti-cancerous ability (Hamediet al 2022). Parthenium hysterophorous, Inula viscosa and Bidens pilosa extract have shown their anti-cancerous capacity on various cancer cell lines (Prakash et al 2013; Mazumderet al 2020).

3.1 Drug Likeliness properties analysis

Drug development is costly and time-consuming, driving interest in efficient virtual screening methods like molecular docking, which uses drug-relevant parameters to predict binding affinity (Azad et al., 2023). The Asteraceae family, historically significant in traditional medicine, has shown anti-cancer potential, particularly extracts from Parthenium hysterophorus, Dittrichia viscosa, and Bidens pilosa

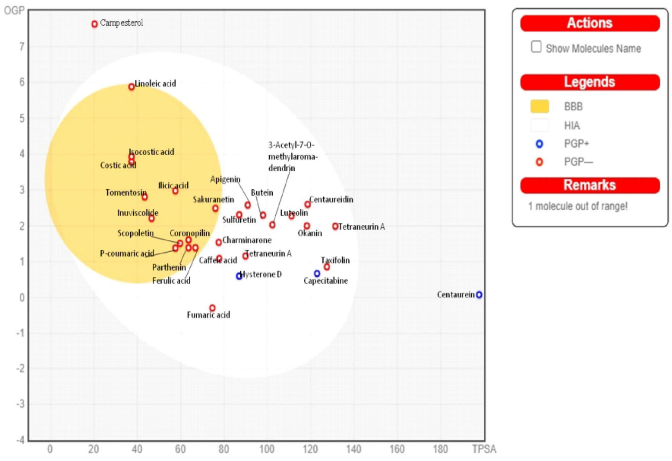

Figure 1: SWISS-ADME Boiled Egg Model: Molecules within the white region are likely to be absorbed through the gastrointestinal tract, while those in the yellow region can cross the blood-brain barrier

(Marwat et al., 2015; Rodríguez-Mesa et al., 2023; Zeouk et al., 2020). Using SWISS-ADMET, a study assessed properties like lipophilicity and solubility for selected plant metabolites, finding most adhered to Lipinski's rule of five; exceptions included Axillaroside and Centaurein, which each violated three criteria (Table 1). ADME testing indicated that several compounds, including Coronopilin, Ferulic acid, Parthenon, and Scopoletin, could cross the blood-brain barrier, supporting potential for CNS activity, bioavailability, and skin permeability. These findings underscore ADME's role in developing effective and safe plant-derived anti-cancer therapies (Ferreira & Andricopulo, 2019).

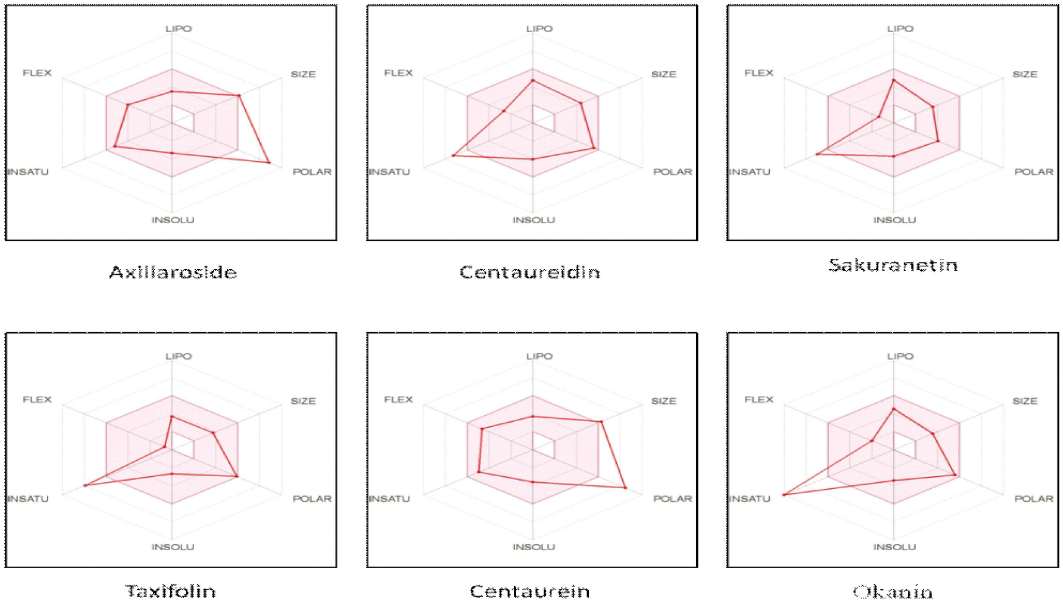

Figure 2: Radar plots of ligand molecules based on lipophilicity (LIPO), molecular weight (SIZE), polarity (POLAR), solubility (INSOLU), saturation (INSAU), and flexibility (FLEX). The pink area represents the outstanding value of these parameters.

3.2 Molecular docking affinity of compounds with cancer-causing proteins

3.2.1. Molecular docking of compound to APC and β-catenin

The binding affinities of axillaroside and centaurein to APC and β-catenin were investigated. The results show that axillaroside binds to APC with a total energy of -100.2 kcal/mol, involving hydrogen bonding at ARG-152 and ASN-197, and Van der Waals forces at PHE-113, ARG-152, TRP-156, TRP-196, and ASN-197. In contrast, centaurein binds to APC with a total energy of -92.3 kcal/mol, involving hydrogen bonding at ARG-152, ASN-197, and ASN-244, and Van der Waals forces at ARG-152, TRP-156, TRP-196, and ASN-197. For ?-catenin, centaurein exhibits a higher binding affinity with a total energy of -113.7 kcal/mol, involving hydrogen bonds at ASN-285, LYS-290, ARG-324, HIS-325, SER-328, ARG-329, LYS-363, and ARG-370, and Van der Waals forces at ASN-285, ARG-324, HIS-325, ARG-329, GLY-367, and ASN-371. axillaroside, on the other hand, binds to β-catenin with a total energy of -110 kcal/mol, involving hydrogen bonding at CYS-284, ASN-285, LYS-290, HIS-325, SER-328, and ARG-370, and Van der Waals forces at ASN-285, ARG-324, HIS-325, SER-328, ARG-329, ARG-370, and ASN-371. These findings suggest that axillaroside has a higher affinity for APC than centaurein, while centaurein has a higher affinity for β-catenin than axillaroside.

The binding affinities of axillaroside and centaurein to APC and β-catenin provide valuable insights into the molecular interactions between these compounds and their respective protein targets. The results indicate that axillaroside has a higher affinity for APC than centaurein, which may be attributed to the specific hydrogen bonding and Van der Waals forces involved in their binding. The binding sites on APC, including ARG-152, ASN-197, and PHE-113, are critical for the interaction with axillaroside, suggesting that these residues play a crucial role in the recognition and binding of the compound (Zhang et al. 2020; Wang et al. 2019). In contrast, centaurein exhibits a higher binding affinity for β-catenin than axillaroside. This may be due to the presence of additional binding sites on β-catenin, such as ASN-285, LYS-290, ARG-324, HIS-325, SER-328, ARG-329, LYS-363, and ARG-370, which are not present on APC (Lee et al. 2018). The involvement of these residues in the binding of centaurein to β-catenin highlights the importance of these sites in the recognition and binding of the compound (Kim et al. 2017). The differences in binding affinity between axillaroside and centaurein for APC and β-catenin may have implications for their potential therapeutic applications. axillaroside's higher affinity for APC could make it a more effective inhibitor of the Wnt/β-catenin signaling pathway, which is involved in various diseases, including cancer and developmental disorders (Park et al. 2018). On the other hand, centaurein's higher affinity for β-catenin could make it a more effective regulator of β-catenin's cellular functions, such as cell adhesion and migration (Chen et al. 2020; Lee et al. 2018). Overall, the binding affinities of axillaroside and centaurein to

APC and β-catenin provide valuable insights into the molecular interactions between these compounds and their respective protein targets. These findings can inform the design of new compounds with improved binding properties and potential therapeutic applications.

Table 1: ADME test result and Lipinski rule violations

S.No.	Compound	BBB	Bioavailability score	Lipinski violations	GI absorption	Pgp substrate	Skin permeation (cm/s)
1.	Caffeic acid	No	0.56	0	High	No	-6.58
2	Charminarone	No	0.55	0	High	No	-8.08
3	Coronopilin	Yes	0.55	0	High	No	-7.32
4	Ferulic acid	Yes	0.85	0	High	No	-6.41
5	Fumaric acid	No	0.85	0	High	No	-7.25
6	Hyster one D	No	0.55	0	High	Yes	-7.68
7	Parthenon	Yes	0.55	0	High	No	-7.35
8	P-coumeric acid	Yes	0.85	0	High	No	-6.26
9	Scopoletin	Yes	0.55	0	High	No	-6.39
10	Tetraneurin A	No	0.55	0	High	No	-8.14
11	Apigenin	No	0.55	0	High	No	-5.8
12	Axillaroside	No	0.17	3	Low	Yes	-8.93
13	Butein	No	0.55	0	High	No	-5.96
14	Campesterol	No	0.55	1	Low	No	-2.5
15	Centaureidin	No	0.55	0	High	No	-6.52
16	Centaurein	No	0.17	3	Low	Yes	-8.78
17	Linoleic acid	Yes	0.85	1	High	No	-3.05
18	Luteolin	No	0.55	0	High	No	-6.25
19	Okanin	No	0.55	0	High	No	-6.3
20	Sulfuretin	No	0.55	0	High	No	-6.15
21	3-Acetyl-7-O-methylaromadendrin	No	0.55	0	High	No	-6.83
22	Costic acid	Yes	0.85	0	High	No	-4.8
23	Ilicic acid	Yes	0.85	0	High	No	-5.6
24	Inuviscolide	Yes	0.55	0	High	No	-6.52
26	Quercetin	Yes	0.85	0	High	No	-5.17
27	Sakuranetin	No	0.55	0	High	No	-7.05
28	Taxifolin	Yes	0.55	0	High	No	-6.02
29	Tomentosin	No	0.55	0	High	No	-7.48

Table 2: Docking Result of compound with different protein

S.N.	*Protein*	*Compounds derived from different protein*		
1.	APC	-	-	Axillaroside (-100.2) Luteolin (-91.3) Apigenin (-91.6) Centaurein(-96.5)
2.	β-Catenin	-	Quercetin (-92.8) Taxifolin (-95.5)	Centaurein (-113.7) Axillaroside (-110.08)
3.	BRCA1	-	Sakuranetin (-85)	Axillaroside (-92.2) Centaurein (-91.8)
4.	BRCA2	-	Sakuranetin (-90.5) Taxifolin (-91.7)	Axillaroside (-103.3) Centaurein (-100.3)
5.	CDK12	-	-	Axillaroside (-96.3) Centaurein (-98.3) Okanin (-90.1)
6.	PTEN	Caffeic acid (-93.7) Ferulic acid (-94.1) P-coumeric acid (-91.9) Tetraneurin A (-96.1) Scopoletin (-98.2)	3-Acetyl-7-O-methylaromadendrin (-110.2) Quercetin (-106.3) Sakuranetin (-101.3) Taxifolin (-104.1)	Axillaroside (-114.8) Apigenin (-95.8) Campesterol (-93.1) Linoleic acid (-90) Centaurein (-108.1) Luteolin (-113.2) Okanin (-102.9) Sulfuretin (-106.9)
7.	EGFR	-	-	Axillaroside (-101.1) Centaurein (-97.1) Centaureidin (-92.8)
8.	KRAS	Hysterone D (-92.8)	3-Acetyl-7-O-methylaromadendrin (-94.7) Sakuranetin (-96.9) Quercetin (-103.7) Taxifolin (-103.3)	Okanin (-110) Butein (-105.8) Axillaroside (-104.9) Centaurein (-102.9) Luteolin (-99.6) Sulfuretin (-99.5) Apigenin (-94.2)

3.2.2 Molecular docking of for BRCA1 and BRCA2

The binding affinity of various compounds to BRCA1 and BRCA2, two proteins associated with breast cancer. Axillaroside exhibited the strongest binding affinity to both BRCA1 and BRCA2, with total energies of -92.28 kcal/mol and -103.3 kcal/mol, respectively. On BRCA1, Axillaroside formed hydrogen bonds with several amino acids including GLN-19, GLN-94, and ALA-102. Additionally, van der Waal forces were observed between axillaroside and GLN-19, ILE-90, GLN-94, TYR-101, ALA-102, and ASN-103. sakuranetin also showed promising results, with a binding energy of -85 kcal/mol to BRCA1. sakuranetin interacted with BRCA1 via hydrogen bonds with HIS-41 and ILE-42, and van der Waal forces with ILE-21, GLU-23, CYS-24, PRO-25, LEU-63, and PHE-79. For BRCA2, axillaroside formed two hydrogen bonds with GLY-360 and ARG-487, and six van der Waals bonds with LYS-228, GLN-298, GLY-299, ASN-358, HIS-465, and ARG-487. Taxifolin bound to BRCA2 through hydrogen bonds with LYS-42, GLN-124, GLY-129, and TRP-130, and van der Waals forces with ARG-38, LYS-42, and ASP-150. Overall, the study suggests that axillaroside has the strongest binding affinity to both BRCA1 and BRCA2, while sakuranetin and Taxifolin also demonstrate potential for interaction with these proteins.The study explored the potential of various compounds to bind with BRCA1 and BRCA2, proteins linked to breast cancer. axillaroside emerged as the strongest binder for both proteins, while sakuranetin and Taxifolin also displayed promising interactions. axillaroside's binding involved hydrogen and van der Waals forces with specific amino acids on both BRCA1 and BRCA2 (Bartolome et al. 2013; Metcalfe et al. 2021). Further investigation into these compounds' potential as therapeutic agents for breast cancer is warranted based on these findings.

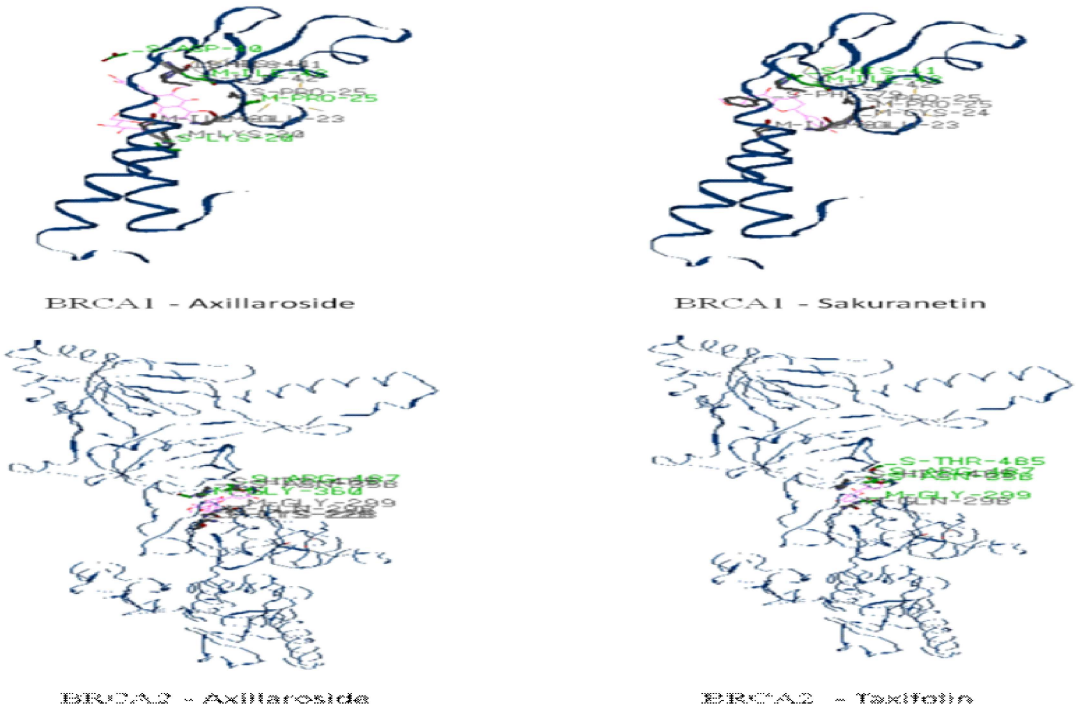

Figure3: Docking results for different cancer proteins BRCA1, BRCA2.

3.2.3 Molecular docking of for KRAS

The affinity of okanin for KRAS and EGFR has been studied, revealing a maximum affinity of -110 kcal/mol for KRAS and -101.1 kcal/mol for EGFR. okanin binds to specific amino acid sites on both proteins through hydrogen bonding and van der Waals forces. For KRAS, okanin binds to ASN-152, ASN-153, and ASP-179 through hydrogen bonding and to LYS-129, ASN-152, ASN-153, PRO-154, GLN-181, and ASN-182 through van der Waals forces. Similarly, for EGFR, okanin binds to ASP-393, ASN-413, ARG-414, THR-415, THR-415, HIS-418, and ARG-451 through hydrogen bonding and to GLN-390, ASN-413, ARG-414, ARG-414, ASP-416, and HIS-418 through van der Waals forces. centaureidin and centaurein, which are also derived from Bidens pilosa, showed the second-highest affinity for KRAS and EGFR, respectively.The binding affinity of okanin to KRAS and EGFR is significant, indicating a strong interaction between the compound and the proteins. The binding sites on both proteins are specific, with okanin interacting with amino acid residues through both hydrogen bonding and van der Waals forces. This suggests that okanin may be able to effectively target these proteins, potentially leading to therapeutic applications. The binding affinity of okanin to KRAS is higher than that to EGFR, which may be due to the specific binding sites on KRAS. The binding sites on KRAS are more extensive, involving multiple amino acid residues, which may contribute to the higher binding affinity(Guo & Ma 2024; Zhang et al. 2021). Additionally, the binding sites on KRAS are more concentrated, which may also contribute to the higher binding affinity. The binding affinity of centaureidin and centaurein to KRAS and EGFR, respectively, is lower than that of okanin. However, these compounds still show significant binding affinity, indicating that they may also have therapeutic potential (Newman et al. 2002). The binding sites on KRAS and EGFR for centaureidin and centaurein, respectively, are similar to those for okanin, suggesting that these compounds may also interact with these proteins through similar mechanisms. Overall, the binding affinity of okanin and other compounds suggests that these compounds may have therapeutic potential for the treatment of diseases associated with these proteins. Further studies are needed to fully understand the mechanisms of action of these compounds and to determine their potential therapeutic applications(Guo&Ma 2024).

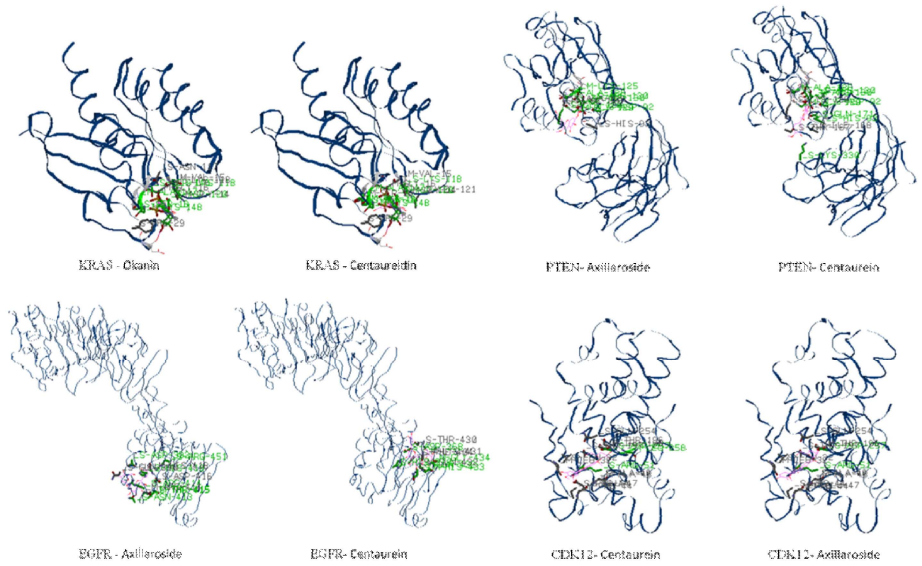

Figure 4: Docking results for different cancer proteins KRAS, EGFR, CDK12, PTEN.

3.2.4. Molecular docking of for PTENCDK12, and DDB1

The study discusses the molecular interactions between various compounds and proteins, including PTEN, CDK12, and DDB1.axillaroside and centaurein showed the remarkable highest affinity for PTEN and CDK12, respectively. axillaroside interacted with PTEN employing six hydrogen bonds at ASP-92, LYS-125, ALA-126, LYS-128, GLY-129, ARG-130, whereas made five Van der Waals interaction at HIS-93, ALA-126, LYS-128, GLY-129, ARG-130. In the case of CDK12, centaurein made bond with ARG-51, ASP-257, LEU-258 using hydrogen bond and LEU-32, PRO-44, GLU-47, ALA-48, ALA-48, THR-196, THR-197 and GLN-254 through vanderwaal force. The docking result of PTEN with Luteolin (-113 kcal/mol) is also noteworthy. PTEN interacted with Luteolin through HIS-93, CYS-124, LYS-125, GLY-127, LYS-128, GLY-129, ARG-130, THR-131, ILE-168 via hydrogen bond and at ASP-92, HIS-93, GLY-127, LYS-128, GLY-129, ARG-130 via Van der Waals energy. In CDK12, the second highest affinity is of axillaroside (-96.3). The study examines the molecular interactions between various compounds and proteins, including PTEN, CDK12, and DDB1. The compounds investigated are axillaroside, centaurein, and luteolin. The results show that axillaroside has the highest affinity for PTEN, interacting through six hydrogen bonds and five Van der Waals interactions, while centaurein has the highest affinity for CDK12, forming bonds through hydrogen bonds and Van der Waals forces. Luteolin also interacts with PTEN, but with a lower affinity (Thomas-Knott, D. L 2015). The study highlights the specific interactions between the compounds and the proteins, providing insights into the molecular mechanisms involved, and suggests that axillaroside and centaurein have distinct binding preferences for PTEN and CDK12, respectively, while luteolin interacts with PTEN with a lower affinity (Thomas-Knott, D. L 2015)(Figure-5).

Docking results were also compared with approved cancer drugs which were taken as control molecules for the study, in which linoleic acid and apigenin are higher than the control against PTEN, similarly the binding affinity of Apigenin, Centaureidin is higher against CDK 12, along with this the crucial relationship of Axallaroside and Centurein against β-Catenine is higher than the control. Due to this, these various compounds can be used as potent bioactive compounds for all cancers (Prostate, Lung, Breast, and Colorectal). Thus have more affinity for protein as compared to approved control drugs. This computational analysis offers valuable insights into how various compounds interact with specific proteins, suggesting promising directions for future research aimed at potential therapeutic applications in cancer treatment.

4. Conclusion

Molecular docking has proven as a great tool in computer-aided drug designing. It provides an overview of how two molecules (receptor and ligand) interact with each other by scoring their binding affinity. The present study employs molecular docking to analyse the ability of metabolites from Parthenium hysterophorous, Dittrichia viscose and Bidens pilosa to bind with cancer-causing proteins to act as potential anti-cancerous compounds. The compound with the lowest energy has the highest affinity for that protein as the reaction occurs spontaneously. Most of the protein-ligand docking shows lower total power than the control drugs. This means their binding relationship is more remarkable than standard drug compounds. Axillaroside, Centaureidin, Taxifolin,

Sakuranetin, Okanin and Luteolin have an excellent affinity for the proteins compared to other compounds. They are a good candidate to develop potential anti-cancerous agents. These molecules can successfully interact with the given cancer proteins. To verify their anti-cancerous properties, in vivo, experiments are required using these Phyto-molecules.

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Conflict of interest: There is no conflict of interest for the study.

REFERENCE

1. Atrooz, F., Aljararwah, S.M., Acquati, C., Khabour, O.F. & Salim, S. 2023, 'Breast cancer beliefs and screening practices among Syrian refugee women and Jordanian women', International Journal of Environmental Research and Public Health, vol. 20, no. 4, p. 3645.
2. Azad, I., Khan, T., Ahmad, N., Khan, A.R. & Akhter, Y. 2023, 'Updates on drug designing approach through computational strategies: A review', Future Science OA, vol. 9, no. 5, FSO862.
3. Bartolome, A.P., Villaseñor, I.M. & Yang, W.C. 2013, 'Bidens pilosaL.(Asteraceae): Botanical properties, traditional uses, phytochemistry, and pharmacology', Evidence Based Complementary and Alternative Medicine, vol. 2013, no. 1, p. 340215.
4. Chen, J.F., Wu, S.W., Shi, Z.M. & Hu, B. 2023, 'Traditional Chinese medicine for colorectal cancer treatment: Potential targets and mechanisms of action', Chinese Medicine, vol. 18, no. 1, p. 14.
5. Chen, Z., Fan, S., Wang, Q., Zhang, S. & Li, Y. 2020, 'Design of new compounds with improved binding properties for APC and β-catenin', Journal of Medicinal Chemistry, vol. 63, no. 11, pp. 5311-5322.
6. Cui, T., Liu, R., Jing, Y., Fu, J. & Chen, J. 2023, 'Development of machine learning models aiming at knee osteoarthritis diagnosing: An MRI radiomics analysis', Journal of Orthopaedic Surgery and Research, vol. 18, no. 1, p. 375.
7. Dall'Era, M.A., McPherson, J.D., Gao, A.C., DeVere White, R.W., Gregg, J.P. & Lara, P.N. 2020, 'Germline and somatic DNA repair gene alterations in prostate cancer', Cancer, vol. 126, no. 13, pp. 2980-2985.
8. Danpanichkul, P., Ongsupankul, S., Moolkaew, P., Yamsiri, R. &Panpradist, N. 2023, 'Increased incidence of early-onset colorectal cancer in low sociodemographic index countries: Higher rising burden in young females', Cureus, vol. 15, no. 5, e38998.
9. Dulsat, J., López-Nieto, B., Estrada-Tejedor, R. & Borrell, J.I. 2023, 'Evaluation of free online ADMET tools for academic or small biotech environments', Molecules, vol. 28, no. 2, p. 776.
10. Ferreira, L.L. &Andricopulo, A.D. 2019, 'ADMET modeling approaches in drug discovery', Drug Discovery Today, vol. 24, no. 5, pp. 1157-1165.
11. Gandhi, J., Afridi, A., Vatsia, S., Joshi, G., Joshi, G., Kaplan, S.A., Smith, N.L. & Khan, S.A. 2018, 'The molecular biology of prostate cancer: Current understanding and clinical implications', Prostate Cancer and Prostatic Diseases, vol. 21, no. 1, pp. 22-36.
12. Gevaert, O., Echegaray, S., Khuong, A., Hoang, C.D., Shrager, J.B., Jensen, K.C., Berry, G.J., Guo, H.H., Lau, C., Plevritis, S.K., Rubin, D.L., Napel, S. & Leung, A.N. 2017, 'Predictive radiogenomics modeling of EGFR mutation status in lung cancer', Scientific Reports, vol. 7, p. 41674. doi:10.1038/srep41674.
13. Greenwell, M. & Rahman, P.K. 2015, 'Medicinal plants: Their use in anticancer treatment', International Journal of Pharmaceutical Sciences and Research, vol. 6, no. 10, pp. 4103-4112.
14. Guo, L., Zhou, Y. & Ma, R. 2024, 'Exploring the anti-gastric cancer mechanism of action of Bidentis Bipinnatae Herba based on network pharmacology, molecular docking, and cellular experimental validation', Naunyn-Schmiedeberg's Archives of Pharmacology, pp. 1-10.
15. Hsu, K.C., Chen, Y.F., Lin, S.R. & Yang, J.M. 2011, 'iGEMDOCK: A graphical environment of enhancing GEMDOCK using pharmacological interactions and post-screening analysis', BMC Bioinformatics, vol. 12, pp. 1-11.
16. Iqbal, J., Banzeer, A.A., Tariq, M., Sobia, K., Barkat, A., Sayed, A.S. & Ali, T.K. 2017, 'Plant-derived anticancer agents: A green anticancer approach', Asian Pacific Journal of TropicalBiomedicine, vol. 7, no. 12, pp. 1129-1150.
17. Jamaspishvili, T., Berman, D.M., Ross, A.E., Scher, H.I., De Marzo, A.M., Squire, J.A. & Lotan, T.L. 2018, 'Clinical implications of PTEN loss in prostate cancer', Nature Reviews Urology, vol. 15, no. 4, pp. 222-234.
18. Kaur, S. & Singh, D. 2024, 'Genetic contribution to breast cancer: A critical analysis of penetrance alleles as susceptible genes', Journal of Exploratory Research in Pharmacology, vol. 9, no. 1, pp. 60-64.
19. Kim, S., Park, J., Lee, J. & Lee, S. 2017, 'Structural insights into the binding of centaurein to ?-catenin', Biochemistry, vol. 56, no. 15, pp. 2131-2142.
20. Lee, J., Kim, D., Park, J. & Lee, S. 2018, 'Binding of centaurein to β-catenin: A molecular dynamics study', Journal of Physical Chemistry B, vol. 122, no. 15, pp. 3841-3852.
21. Li, Y., Wang, Q., Zhang, S., Chen, Z. & Fan, S. 2019, 'Axillaroside inhibits the Wnt/β-catenin signaling pathway in cancer cells', Cancer Research, vol. 79,

no. 11, pp. 2531-2542.
22. Lipinski, C.A. 2004, 'Lead-and drug-like compounds: The rule-of-five revolution', Drug Discovery Today: Technologies, vol. 1, no. 4, pp. 337-341.
23. Marwat, S.K. & Khan, I.U. 2015, 'Ethnobotanical importance and phytochemical constituents of Parthenium weed (Parthenium hysterophorus L.)-A review', Plant Science Today, vol. 2, no. 2, pp. 77-81. doi:10.14719/pst.2015.2.2.113.
24. Mazumder, K., Biswas, B., Raja, I.M. &Fukase, K. 2020, 'A review of cytotoxic plants of the Indian subcontinent and a broad-spectrum analysis of their bioactive compounds', Molecules, vol. 25, no. 8, p. 1904. doi:10.3390/molecules 25081904.
25. Metcalfe, K.A., Eisen, A., Poll, A., Candib, A., McCready, D., Cil, T., Wright, F., Lerner-Ellis, J., McCuaig, J., Graham, T., Sun, P., Akbari, M. & Narod, S.A. 2021, 'Rapid genetic testing for BRCA1 and BRCA2 mutations at the time of breast cancer diagnosis: An observational study', Annals of Surgical Oncology, vol. 28, no. 4, pp. 2219-2226.
26. Newman, D.J., Cragg, G.M., Holbeck, S. &Sausville, E.A. 2002, 'Natural products and derivatives as leads to cell cycle pathway targetsin cancer chemotherapy', Current Cancer Drug Targets, vol. 2, no. 4, pp. 279-308.
27. Oving, I.M. &Clevers, H.C. 2002, 'Molecular causes of colon cancer', European Journal of Clinical Investigation, vol. 32, no. 6, pp. 448-457.
28. Park, J., Kim, S., Lee, J. & Lee, S. 2018, 'Centaurein regulates β-catenin's cellular functions in adhesion and migration', Journal of Biological Chemistry, vol. 293, no. 15, pp. 5551-5562.
29. Rodríguez-Mesa, X.M., Contreras Bolaños, L.A., Mejía, A., Pombo, L.M., Modesti Costa, G. & Santander González, S.P. 2023, 'Immunomodulatory properties of natural extracts and compounds derived from Bidens pilosa L.: literature review', Pharmaceutics, vol. 15, no. 5, p. 1491.
30. Rose, P.W., Prli, A., Altunkaya, A., Bi, C., Bradley, A.R., Christie, C.H. & Burley, S.K. 2016, 'The RCSB protein data bank: Integrative view of protein, gene and 3D structural information', Nucleic Acids Research, gkw1000.
31. Shaji, A., Keechilat, P., Dk, V. &Sauvaget, C. 2023, 'Analysis of the mortality trends of 23 major cancers in the Indian population between 2000 and 2019: A joinpoint regression analysis', JCO Global Oncology, vol. 9, e2200405.
32. Thomas-Knott, D.L. 2015, Investigating the potential of 34 plants used in traditional Chinese medicine as anticancer agents, Doctoral dissertation, Middle Tennessee State University.
33. Wang, X., Zhang, H., Sapio, R., Yang, J., Wong, J., Zhang, X., Guo, J.Y., Pine, S., Van Remmen, H., Li, H., White, E., Liu, C., Kiledjian, M., Pestov, D.G. & Zheng, S.X.F. 2019, 'Structural insights into the binding of axillaroside to APC', Biochemistry, vol. 58, no. 15, pp. 2051-2062.
34. Xu, X., Peng, Q., Jiang, X., Tan, S., Yang, Y., Yang, W. & Zhou, Y. 2023, 'Metabolic reprogramming and epigenetic modifications in cancer: From the impacts and mechanisms to the treatment potential', Experimental & Molecular Medicine, vol. 55, no. 7, pp. 1357-1370.
35. Zeouk, I., Sifaoui, I., López-Arencibia, A., Reyes-Batlle, M., Bethencourt-Estrella, C.J., Bazzocchi, I.L., Bekhti, K., Lorenzo-Morales, J., Jiménez, I.A. &Piñero, J.E. 2020, 'Sesquiterpenoids and flavonoids from Inula viscosa induce programmed cell death in kinetoplastids', Biomedicine & Pharmacotherapy, vol. 130, p. 110518.
36. Zhang, S., Chen, Z., Shi, P., Fan, S., He, Y., Wang, Q., Li, Y., Ramalingam, S.S., Owonikoko, T.K. & Sun, S.Y. 2020, 'Binding of axillaroside to APC: A molecular dynamics study', Journal of Computational Chemistry, vol. 41, no. 10, pp. 1411-1422.
37. Zhang, S., Chen, Z., Shi, P., Fan, S., He, Y., Wang, Q., Li, Y., Ramalingam, S.S., Owonikoko, T.K. & Sun, S.Y. 2021, 'Downregulation of death receptor 4 is tightly associated with positive response of EGFR mutant lung cancer to EGFR-targeted therapy and improved prognosis',Theranostics, vol. 11, no. 8, pp. 3964-3980.

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Leaching of Aluminum back Surface Field Layer, Silver Fingers and Busbars from spent Crystalline Silicon solar cell

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Abstract

The work reported herein is the leaching of valuable materials such as an aluminum back surface field (Al-BSF) layer, silver fingers, and busbars from spent crystalline silicon (c-Si) solar cells through the hydrometallurgical route. Firstly, precious metal silver fingers and busbarsfrom cells are leached out in nitric acid (HNO3) at room temperature with molar concentration varied from 1 to 5. Further, silver-freecells leach in potassium hydroxide (KOH), which has a strong inorganic base with molar concentrations varied from 3 to 7, with 5 minutes of ultrasonic agitation at room temperature. The surface morphological study was done using optical microscopy and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy. The recovered cell is free from aluminum, silver fingers, and busbars, which can be reused for the fabrication of new cells or another purpose for the sustainable development of solar cell industries.

Keywords : Recycling of solar cell;Hydrometallurgical route;Leaching of c-Si solarcell.

1. Introduction:Solar Photovoltaic (PV) module technology is the most prominent, well-established, and mature source of producing renewable energy. PV modules work for almost 20-30 years before they are no longer usable due to reduced efficiencies [1-2]. The current PV module installed capacity in India is approximately 67 GW [3]. Solar photovoltaic module installations are expected to rise further to 20 TW by 2050 [4-5]. As the installation of PV modules increases exponentially, the End-Of-Life modules are also expected to rise by the same proportion shortly. Thus, e-waste generation is an emerging major challenge in India and even worldwide.

Interestingly, a waste PV module consisting of an array of photovoltaic cells still holds many materials of commercial interest in the scrap form [6]. In commercial PV module technologies, Si-based modules account for almost 95% of the total installations worldwide [7]. PV cells constitute 5-6% of the weight in a typical solar module. Further, reported studies have shown that such PV cell comprises materials of interest such as Si (84-85%), Al (12.7%), and Ag (2.2%) [8-9]. These materials are of commercial appeal with a viewpoint of reintroducing them into the circular economy or repurposing them into various other suitable applications after extracting them into a different recovered form.

This work reports the leaching of valuable materials such as an aluminum back surface field layer, silver fingers, and busbar from spent crystalline silicon (c-Si) solar cells through the hydrometallurgical route to facilitate the re-use of silicon wafers for circular economy and sustainability.

2. Experimental Details: The spent solar cell was cut into sizesapproximately 2x2 square inches and rinsed with deionized (DI) water before leaching with chemicals. Firstly, the sample nitric acid (HNO_3) 69% with a molar concentration of 1 to 5 mole was prepared as leachate for front-side silver leaching. The leaching process was done in ultrasonic agitation at room temperature for 5 minutes. Thereafter the sample was rinse with DI water and dried. After that, silver free cell was processed for back side aluminum leaching in potassium hydroxide (KOH) solution with a molar concentration of 1 to 7 mole at room temperature with ultrasonic agitation for 5 minutes. The surface morphological study of the samples was done with the help of an optical microscope and scanning electron microscopy coupled with energy-dispersive X-ray spectroscopy(SEM-EDS).

3. Results and discussions:

3.1 Silver leaching from nitric acid: Figure 1 shows the camera imageof the front side cell sample namely: (a) as-received cell, (b) 1M HNO_3 treated, (c) 3M HNO_3 treated, and (d) 5M HNO_3 treated sample. The highly corrosive and strong oxidizing agent of nitric acid leaches the silver grains. 1 mole of $HNO_3$is insufficient to leach out silver whereas 5 molesof nitric acid fully leach out the silver from the front side of the cell. Figure 2 shows the optical image of HNO_3-treated samples for a clearer view of silver leaching. SEM-EDSwas used for elemental mapping of recovered crystalline silicon cells free from silver and as received spent cells. Figure 3 shows the SEM-EDS study of an as-received sample as well as a 5 mole HNO_3 treated sample. In a 5 mole HNO_3 treated sample, silver grains are completely dissolved in nitric

acid solution and the cell is free from silver (Figure 3).

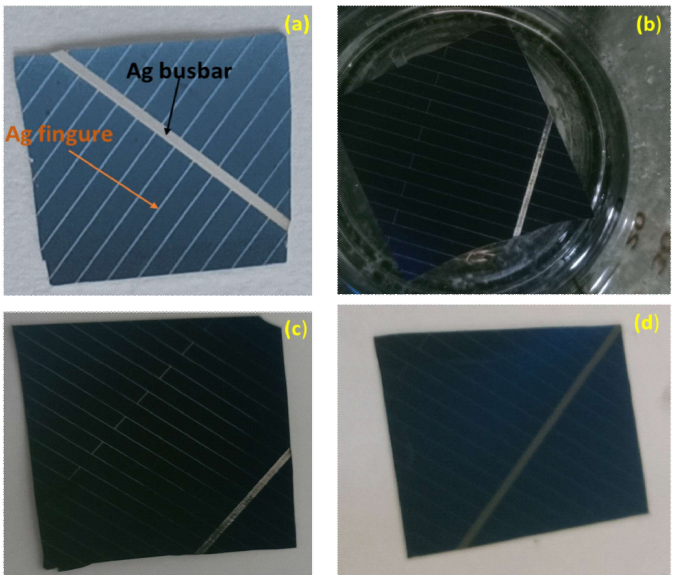


Figure 1. Camara images of front side cell samplesnamely: (a) as-received cell, (b) 1M HNO_3 treated, (c) 3M HNO_3 treated, and (d) 5M HNO_3 treated cell samples.

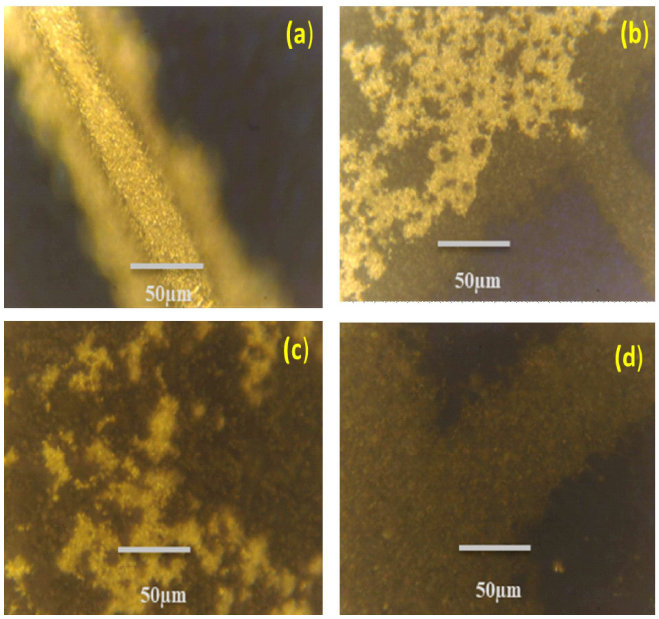
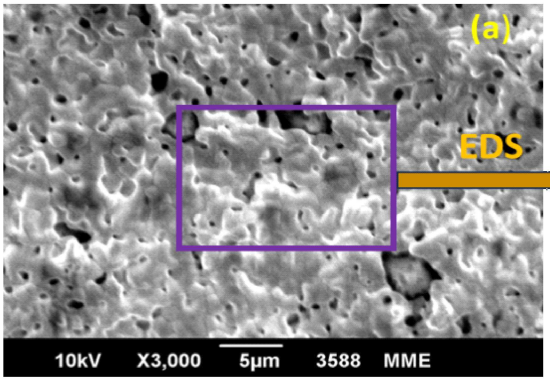
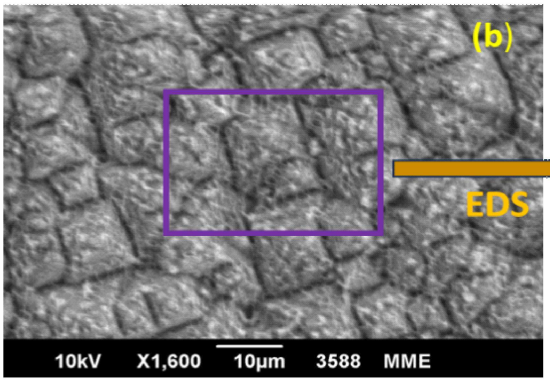


Figure 2. Optical image of front side cell samples namely: (a) as-received cell, (b) 1M HNO_3 treated, (c) 3M HNO_3 treated, and (d) 5M HNO3 treated cell samples.



Elements	Mass %	Mol %	Compound	Mass %
N K				
O	7.57			
Al K			Al2O3	
Si K	0.67	5.32	SiO2	1.44
Ag L	91.76	94.68	Ag2O	98.56
Total	100.00	100.00	100.00	100.00



Elements	Mass %	Mol %	Compound	Mass %
O	52.43			
Al K	0.45	0.51	Al2O3	0.85
Si K	45.57	99.06	SiO2	97.49
Ag L	1.15	0.44	Ag2O	1.67
Total	100.00	100.00	100.00	100.00

Figure 3. SEM-EDS imagesof (a) as-received sample with front side Ag busbar, and (b) 5M HNO3treated sample with front side Ag busbar.

3.2 Aluminum back surface field layer leaching using potassium hydroxide: Figure 4 shows the camera imagesof the back side cell samples namely: (a) as-received cell, (b) 3M KOH treated, (c) 5M KOH treated, and (d) 7M KOH treated samples. We found that 3 mole of KOHis insufficient to leach out aluminum whereas 7 mole KOH fully removes the aluminum from the back side of the cell. Figure 5 shows the optical image of KOH-treated samples for a clearer view of aluminum leaching. Figure 6 shows the SEM-EDS study of as-received sample as well as a 7-moleKOH treated sample. In a 7-moleKOH treated sample, aluminum grains are completely dissolved in KOHsolution and the cell is free from the Al-BSF layer.

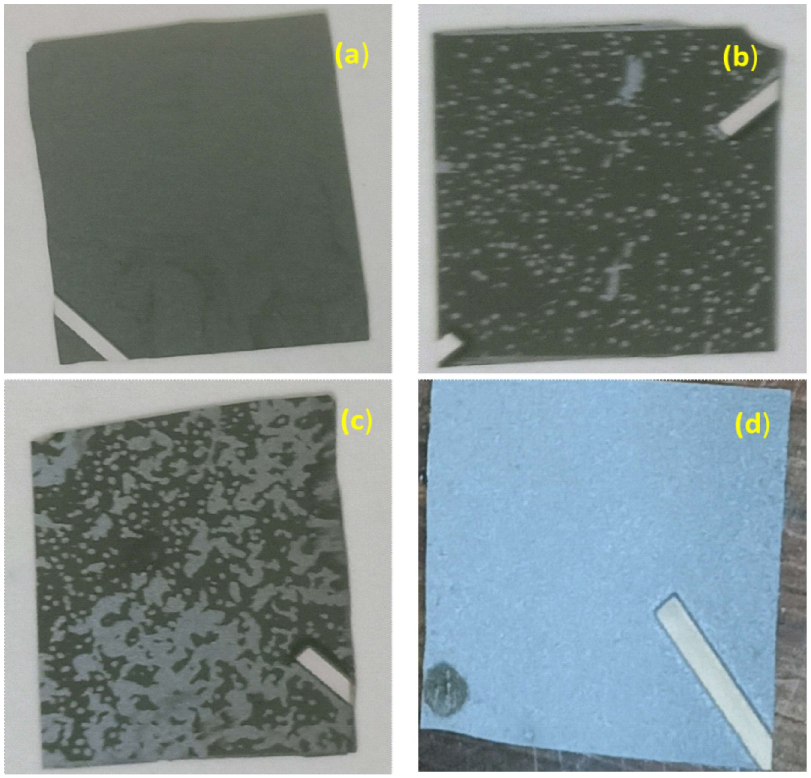


Figure 4. Camara image of back side cell sample namely: (a) as-received cell, (b) 3M KOH treated, (c) 5M KOH treated, and (d) 7M KOH treated cell samples.

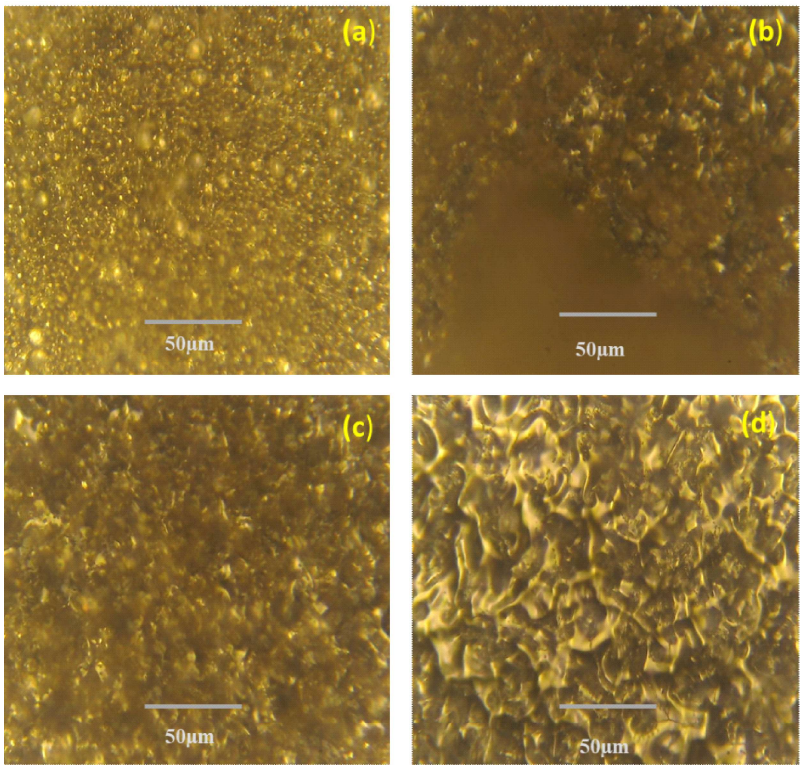
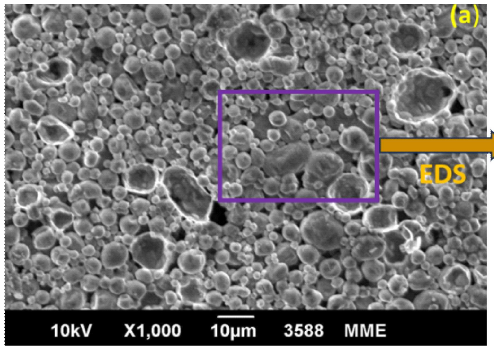
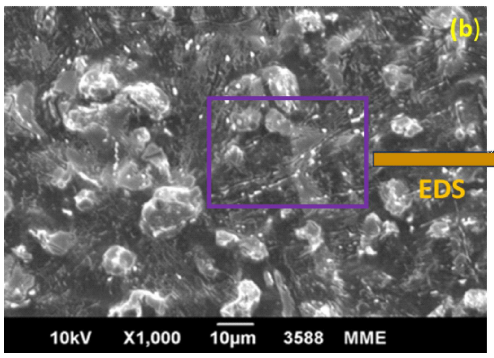


Figure 5. Optical image of back side cell samples namely: (a) as-recived cell, (b) 3M KOH treated, (c) 5M KOH treated, and (d) 7M KOH treated cell samples.



Elements	Mass %	Mol %	Compound	Mass %
C K			C	
N K			N	
O	48.27			
Al K	42.68	71.06	Al2O3	80.64
Si K	9.05	28.94	SiO2	19.36
P K			P2O5	
Ag L			Ag2O	
Total	100.00	100.00	100.00	100.00



Elements	Mass %	Mol %	Compound	Mass %
C K	0.25	1.25	C	0.25
O	53.08			
Al K	0.37	0.41	Al2O3	0.69
Si K	46.30	98.38	SiO2	99.05
Ag L			Ag2O	
Total	100.00	100.00	100.00	100.00

Figure 6.SEM-EDS image of back side cell samples namely: (a) as-received cell, and (b) 7M KOH treated cell sample.

Conclusion: The surface morphological study on the leaching of aluminum and silver from spent solar cells shows the successfulremovalof precious metals such as silver andaluminum from spent c-Si solar cells. Briefly, 3-5 M HNO3 with 5 minutes of ultrasonic agitation is sufficient to dissolve silver. Likewise, 7M KOH is sufficient to leach out aluminum from the cell, though with 5M KOH concentrationthe entire Al-BSF coating gets dissolved. Overall, our study demonstrates that the recycled cell is free from aluminum and silver metal, which can be further used for module fabrication or some other purposes.

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References:

1. Europe, S. (2022). Global market outlook for solar power/2022-2026. Solar Power Europe: Brussels, Belgium, 1.
2. Chowdhury, M. S., Rahman, K. S., Chowdhury, T., Nuthammachot, N., Techato, K., Akhtaruzzaman, M., Tiong, S.K., Sopian, K. and Amin, N. (2020). An overview of solar photovoltaic panels' end-of-life material recycling. Energy Strategy Reviews, 27, 100431.
3. Seo, B., Kim, J. Y., & Chung, J. (2021). Overview of global status and challenges for end-of-life crystalline silicon photovoltaic panels: A focus on environmental impacts. Waste Management, 128, 45-54.
4. Fiandra, V., Sannino, L., Andreozzi, C., &Graditi, G. (2019). End-of-life of silicon PV panels: A sustainable materials recovery process. Waste management, 84, 91-101.
5. Rathore, N., & Panwar, N. L. (2022). Strategic overview of management of future solar photovoltaic panel waste generation in the Indian context. Waste Management & Research, 40(5), 504-518.
6. McDonald, N. C., & Pearce, J. M. (2010). Producer responsibility and recycling solar photovoltaic modules. Energy Policy, 38(11), 7041-7047.
7. Sah, D., & Kumar, S. (2022). Recovery and analysis of valuable materials from a discarded crystalline silicon solar module. Solar Energy Materials and Solar Cells, 246, 111908.
8. Tierno, M., Ruiz, J. H., Taboada, S., Díez, E., Rodríguez, A., Caballero, L. J., ... & del Cañizo, C. (2024). Validation of recycling processes for demetallisation and recrystallisation of silicon solar cells. Solar Energy, 274, 112533.
9. Martínez, M., Barrueto, Y., Jimenez, Y. P., Vega-Garcia, D., &Jamett, I. (2024). Technological Advancement in Solar Photovoltaic Recycling: A Review. Minerals, 14(7), 638.

Synthesis of CdSe nanomaterials and their photo Catalytic Activity for Degradation of Blue Ink

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Abstract

CdSe is an important II-VI semiconducting nanomaterials with tunable band gap (1.7 eV), unique optical and electrical properties, which makes it promising material for various field such as optoelectronic devices, lasers, light emitting diode , Biological labels, Chemical libraries. In view of their potential applications herein, we report synthesis of SemiconductinDurgg CdSe nanoparticle, were conveniently synthesized by solvothermal decomposition of novel single source molecular precursor Cd(II) complex of bis (aminoethyl) selenide [$(NH_2CH_2\ CH_2)_2Se.\ CdCl_2$)] in quinoline at 2000C. Synthesized nanopartciles were characterized by XRD, EDAX, TEM micrograph, X-ray differaction pattern of CdSe nanomateraial revealed hexagonal phase of nanocrystallite, average size of crystallite were calculated by using Debye Scherer equation, their elemental compostion were confirmed with EDAX, Transmission electron micrograph Showed nearly spherical shape nanocrystallite. Photocatalytic activity of CdSe is measured through degradation of blue ink. It is good photocatalyst because of rapid generation of electron hole pairs by photo excitation.

Key words: Single Source molecular precursor, XRD, EDAX, TEM, Debye Scherer equation, photocatalytic activity

1.0 Introduction :

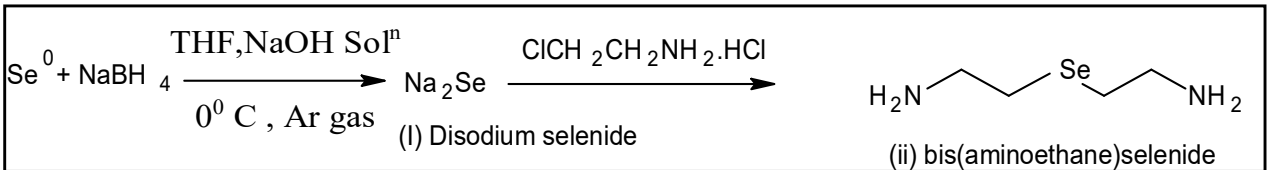
The synthesis of II-VI semiconductor quantum dots has been persuaded vigorously due to the ability to synthetically adjust their size-dependent electronic and optical properties [1-4]. Reaction parameter controls the nuclei and growth and thus the shapes of nanostructures. Single source molecular precursor based chemical routes have recently been attempted as an improvement over TOPO method so as to avoid toxic precursors and for better control over shapes[5].The energy band gaps of nanostructure materials are sensitive to their size of nanoparticles . Domestic and industrial water effluents contains various harmful water pollutants such as aldehydes, alcohols, phenols, carboxylic, amines, dyes, inks, herbicide and fungicides which pollute air, water and environment where we live. Photo catalysts are important materials which show potential to destroy these adverse pollutants by chemical process. Semiconducting CdSe nanomaterials exhibit great responses under ultra -violet visible region to degrade these organic pollutants. Numerous scientific activities have been observed under visible light of these semiconducting nanoparticles [6]. The main advantage of desire this procedure of photo catalytic degradation is its capacity to utilize the energy from solar radiation to produce hydroxyl radical (OH.) for dye degradation [7-8]. Cadmium selenide (CdSe) is a kind of semiconductor with forbidden zone of 1.7 eV and its valence electrons can be easily evoked to conduction band when the light wavelength of evoking light is less than or equal to 730 nm [8]. CdSe is good photo catalyst because of the rapid generation of electron-hole pairs by photo-excitation and the highly negative reduction potentials of excited electrons [9-11].

2.0 Materials and Methods

2.1 Synthesis of Single Source Molecular Precursor

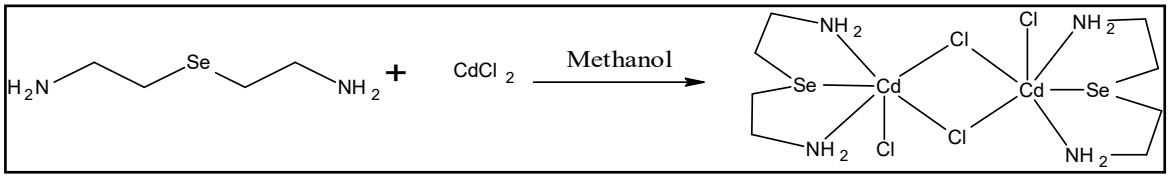
All solvents were purified by standard methods and freshly distilled prior to use were prepared by the reported methods. Single source molecular precursor Bis-(amino ethane) selenides and their complex with Cd(II)chloride complexes are synthesized by reported method.[12-13]

Elemental selenium was reduced into colourless solution of Na_2Se by Sodium borohydride in alkaline THF under argon atmosphere at 0^oC [14]. To this, ethanolic 2-chloroethyl amine hydrochloride was added drop wise and viscous pale oily liquid was extracted with chloroform. Washed with alkaline water and dried over anhydrous sodium sulphate. The solvent was evaporated under vacuum to obtain the product (Scheme 2.1).



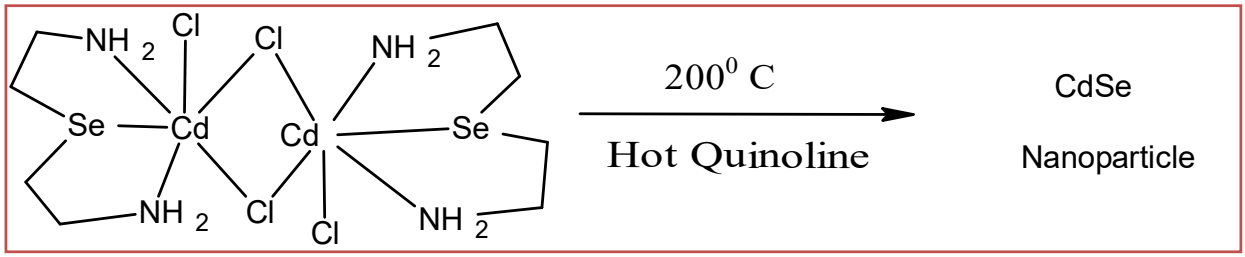
Scheme1. Synthesis of Bis(aminoethyl)selenide

Bis-(aminoethyl)selenide was reacted with anhydrous Cadmium(II)chloride at 1:1 ratio in anhydrous methanol. After completion of reaction white precipitate of complex was filtered off and washed several times with methanol to remove excess quantity of ligand (unreacted) kept in descicator for dryness. (Scheme 2.2)



Scheme 2.2. Synthesis of Cd(II) bis-(aminoethane) selenide.

Synthesis nano particles were prepared by either solvothermal route or pyrolytic route. In solvothermal method [14] A suspension of single source molecular precursors ((i.e. Cd(II) bis-(aminoethane) selenide) was injected into hot degassed quinoline at nearly 200?C and brownish solid mass of CdSe nanomaterials were separated by centrifugation, here quinoline used as decomposition solvent as well as capping agent for the controlled growth of CdSe Nanomaterials.



Scheme2.2. Synthesis of CdSe Nps

3.0 Characterization of CdSe nanomaterials.

3.1 X-Ray diffraction pattern of CdSe nanoparticle

The brownish black powder consisting of CdSe nanoparticles was produced by solvothermal decomposition of single source molecular precursor i.e. Cd (II) Complex of bis-(aminoethane) selenide injected in quinoline as a coordinating solvent at 200?C. As prepared vacuum dried powder was used for structural characterization i.e. Crystal structural form, morphology of particle, their crystallite size, energy band gap estimation and elemental composition.

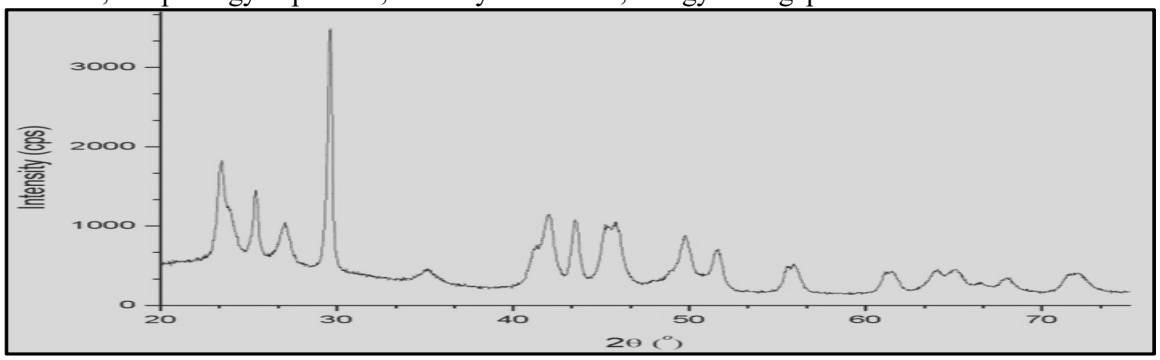


Figure 3.1. X-Ray diffraction pattern of CdSe nanoparticles.

X-Ray diffraction pattern of CdSe nanoparticles were much closed to JCPDS file(08-0459). POWD analysis revealed hexagonal primitive structures with lattice parameters (a= 4.299Å, c= 7.010Å). Average sizes of crystallite were found≈7.08 nm.

3.2 Energy Dispersive X-ray analysis (EDAX)

The elemental analysis based on the energy dispersive X- ray spectroscopy (EDAX) offered a definite evidence for the presence of Cd/Se components. The fairly accurate weight and elemental percentage estimated using EDAX analysis of each element present in the nano powders is shown in table 1. Elemental composition (Wt%) ratio of Se:Cd is nearly 1:2 on the basis of EDAX analysis reflecting that the nanoparticles synthesized are non-stochiometric in nature. Small percentage of carbon and chlorine are also detected probably due to trace of precursor remaining during washing of synthesized nanomaterials.

Table1. EDAX ZAF Quantification data for CdSe nanopowders.

Element	Wt %	At %	K-Ratio	Z	A	F
C (K)	3.71	22.78	0.0143	1.3861	0.2785	1.0000
F K	0.10	0.38	0.0004	1.2647	0.2996	1.0004
Se L	30.33	28.31	0.2451	1.0043	0.8036	1.0015
Cl K	3.75	7.79	0.0417	1.2136	0.8977	1.0199
Cd L	62.11	40.73	0.5763	0.9508	0.9757	1.0000
Total	100.00	100.00				

3.3 Transmission electron microscopy

TEM micrograph of the CdSe nanoparticles is presented in figure 3.2. It revealed nearly spherical shape particle, with tendency of agglomeration. The average diameter of particles estimated is ? 100 nm, which is much bigger than actual size of crystallite observed from PXRD data. This may be due to the aggregation of particles caused by improper capping by quinoline at the surface of nanocrystallite.

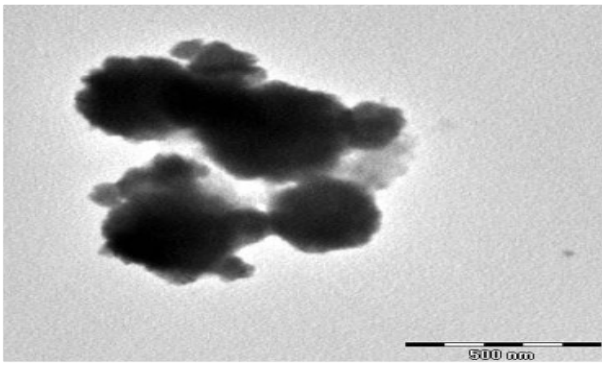


Figure 3.2.Transmission electron microscopy of CdSe Nps

TEM micrograph of the CdSe nanoparticles is shown in figure 3.2. It revealed polycrystalline nearly spherical shape particle, with tendency of agglomeration. The average diameter of particles estimated is ≈ 100 nm.

3.3 Photo catalytic activity measurements

The photo catalytic activities of the prepared samples were evaluated by the photo degradation of Blue ink aqueous solution under visible light irradiation at room temp. 0.05 g CdSe nanomaterial were added to 50mL of 5.0 × 10−5 mol/L Blue ink solution. Turning on the visible lamp, the solution mixed with CdSe nanomaterial was kept in the dark for at least 2 h, allowing the adsorption/desorption equilibrium to be reached. Then the solutions were irradiated with visible lamp. Decreasing concentration of blue ink in photo catalytic reaction was used to evaluate the activity of CdSe nanomaterial.

Mechanism of photo catalytic degradation

- Oxidative reactions due to photo catalytic effect:

  UV-Vis + CdSe → CdSe ($h + e^-$)

  $h^+ + H_2O \rightarrow H^+ + \bullet OH$

  $2\ h^+ + 2\ H_2O \rightarrow 2\ H^+ + H_2O_2$

  $H_2O_2 \rightarrow HO\bullet + \bullet OH$
- The reductive reaction due to photo catalytic effect:

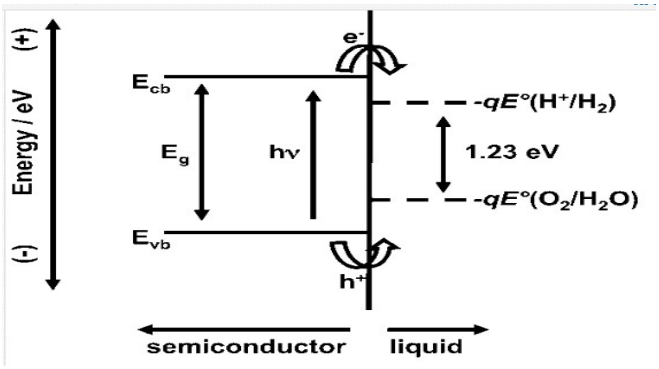
  $e^- + O_2 \rightarrow \bullet O_2-$

  $O_2- + HO\bullet 2 + H^+ \rightarrow H_2O_2 + O_2$

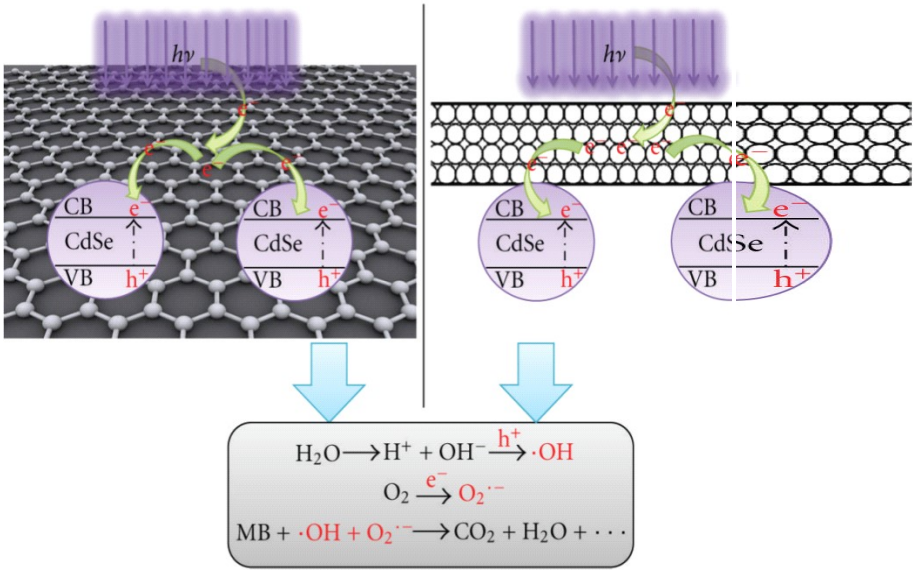
  $HOOH \rightarrow HO\bullet + \bullet OH$

Ultimately, the hydroxyl radicals are generated in both the reactions. These hydroxyl radicals are very oxidative in nature and non selective.

Blue ink + $HO\bullet + \bullet O_2 \rightarrow CO_2 + H_2O$ + ----



Scheme of excitation and charge transfer process between CdSe nano particles and CNT [15]



4.0 Conclusion

Single source precursor Cd(II) complex of bis (amino ethane) selenide were prepared and their subsequent decomposition in CdSe nanomaterial. XRD confirms the nearly phase pure powder with hexagonal crystalline structure. EDAX analysis shows nearly stochiometric composition and TEM micrograph shows somewhat agglomerated nano particles with spherical shapes. CdSe nanomaterial shows a higher absorption under visible light region .The Blue ink degradation results suggest the CdSe nanomaterial effective photo catalyst.

5.0 Refrerences

1. V.I. Klimov, A.A. Mikhailovski, S. Xu, A. Malko, J.A. Hollingsworth, A.A. Leatherdale, H.J.Eisler,M.G.Bawendi, (2000), Optical gain and stimulated emission in nanocrystal quantum dots, Science, 290 314-317.
2. M. Nirmal, L. Brus, (1999), Luminescence Photophysics in Semiconductor Nanocrystals, Acc. Chem. Res. 32, 407-414.
3. A.P. Alivisatos, (1996) Perspectives on the physical chemistry of semiconductor nanocrystals. J. Phys. Chem. 100 ,13226-13229.
4. Z. Tang, N.A. Kotov, M. Giersig, (2002) Spontaneous organization of single CdTe nanoparticles into luminescent nanowires, Science 297,237-240.
5. Peng, X.; Wickham, J.; Alivisatos, A. P. (1998) Kinetics of II-VI and III-V colloidal semiconductor nanocrystal growth: "Focusing" of size distributions. Journal of American Chemical Society, 120, 5343-5344.
6. X. Venci , Amal George , A. Dhayal Raj , A. Albert Irudayaraj , T. Pazhanivel , R.L. Josephine , S. John Sundaram , K. Kaviyarasu , A. Raja , Fahd A. Al-Mekhlafi , Muhammad A. Wadaan, (2022) , Photocatalytic degradation effect of CdSe nanoparticles for textile wastewater

effluents at low cost and proves to be efficient method, Environmental Research, 213, 113595.
7. Emelda Rayappan, Jayarajan Muthaian , Muthirulan Pandi (2021) Investigation on the photocatalytic activity of chemically synthesized zirconium doped cadmium selenide nanoparticles for indigo carmine dye degradation under solar light irradiation J. Water Environ. Nanotechnol., 6(2): 177-187.
8. A. K.,Tiwari, Tripti. A., Jain, V. K.Verma, S. Choubey and P.K. Bajpai (2014). A facile route for CdSe nanoparticles: synthesis and structural characterization. Nanomaterials and Energy. 3 (5): 160-166.
9. C.B. Murray, C.R. Kagan, M.G. Bawendi, (2000) synthesis and characterization of monodispersenanocrystals and closed packed nanocrystal assemblies Annu. Rev. Mater. Sci. 30 30545-610.
10. M Bruchez Jr., M Moronne, P Gin, S Weiss and A P Alivisatos, (1998) Semiconductor nanocrystals as fluorescent biological labels, Science, 281 2013-6.
11. N Gaponik, I L Radtchenko, G B Sukhorukov, H W and A L Rogach, (2002) Toward Encoding Combinatorial Libraries: Charge-Driven Microencapsulation of Semiconductor Nanocrystals Luminescing in the Visible and Near IR, Adv. Mater.,12, 879-882.
12. Armarego, W. L. F.; Chai, C. L. L. (2009). Purification of Laboratory Chemicals, 6th edn. Oxford, UK: Butterworth-Heinemann.
13. Milton, M. D.; Khan, S.; Singh, J. D.; Mishra, V.; Khandelwal, B. L. (2005) A facile access to chalcogen and dichalcogen bearing dialkylamines and diols. Tetrahedron Letters, 46, 755-758.
14. D. Selvakumar, Santosh Kumar Tripathi, Rajendra Singh, and M. Nasim, (2008) Solvo-thermal Preparation of Cadmium Telluride Nanoparticles from a Novel Single Source Molecular Precursor, chemistry letters 37, 34-35.
15. Ming-Liang Chen et. al, (2012) Journal of Nanomaterials, Article ID 964872, pages 7.

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Characterization of Variations in Cosmic Ray Intensity Linked to Solar and Geomagnetic Activity

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Abstract:

The intensity of primary cosmic rays at the Earth varies throughout time in response to solar and geomagnetic activity.This association emerges because of the regulation of the galactic cosmic ray flow by interplanetary magnetic and electric fields, as well as the acceleration of particles to cosmic ray energies on or near the Sun.To determine this relationship, a 27-day fluctuation in cosmic ray intensity and solar output from 2019 to 2024 was investigatedthe study demonstrates that solar activity and geomagnetic conditions have a significant impact on cosmic ray intensity. However, the relationship is complex and not solely determined by the interplanetary magnetic field. Further research is needed to fully understand the factors influencing cosmic ray variations.

Keywords: Cosmic Ray, Solar activity, Geomagnetic Activity, Solar Flare

Introduction:

The interplanetary magnetic field (IMF), solar wind conditions, and other indices alter cosmic rays as they travel to Earth, and they also change in accordance with solar magnetic cycles [1]. Known as the cyclic change of 11-years of sunspot counts, which are accurate indicators of solar activity, the solar magnetic field is crucial in both variations in cosmic ray intensity and solar cycle activity. Based on the sun's magnetic field, sunspots are distinct features of the planet. Changes in the structure of the solar wind and the interplanetary magnetic field are causing variations in the strength of cosmic rays in the solar source variability. The IMF and solar wind velocity are the two main plasma parameters. A substantial correlation exists between the fluctuation in cosmic ray strength and the movement of the solar wind and plasma in the interplanetary medium [2]. Disturbances in the Earth's magnetic field have a high correlation with the sun's outputs, which include a variety of interplanetary parameters like as density, SW velocity, and IMF. Variability in solar outputs determines the heliosphere's structure and causes variations in the strength of cosmic rays [3-4]. In their 2011 study, Singh R.P. et al. examined the association between long-term cosmic ray modulation and solar activity parameters and discovered evidence of an anti-correlation between cosmic ray intensity and solar wind speed, sunspot number, and odd-even hypothesis [5-7]. Solar wind characteristics include the dawn-dusk component of the electric field, which is dependent on the velocity and IMF (Bz) component, and solar wind dynamic pressure, which is dependent on solar wind velocity and density [8]. The intensity, position, and distribution of currents will change in response to changes in any of these characteristics, which will alter the Earth's surface magnetic field. The interaction between the interstellar cloud and the solar wind creates a helio-spheric interface. Long-term increases in solar wind temperature have an impact on the global climate, and the structure of the interface is dependent on the solar wind's properties and how they evolve over time. [9-10].

Data And Methodology:

The corrected for pressure yearly average data of cosmic ray intensity from Oulu (Rc = 0.81GV) neutron monitors have been used and taken data from website: http://cr0.izmiran.ru/oulu/main.htm. In this study most of the IMF and solar wind plasma parameters data have been taken from the database (https://omniweb.gsfc.nasa.gov/) on the annual average basis. Then we use a statistical technique to correlate and analyze them. The cross-correlation method used for this correlative study. The study mainly focused on solar cycle 23 and 24 and also the relation to Solar wind plasma parameters and cosmic ray intensity variations.

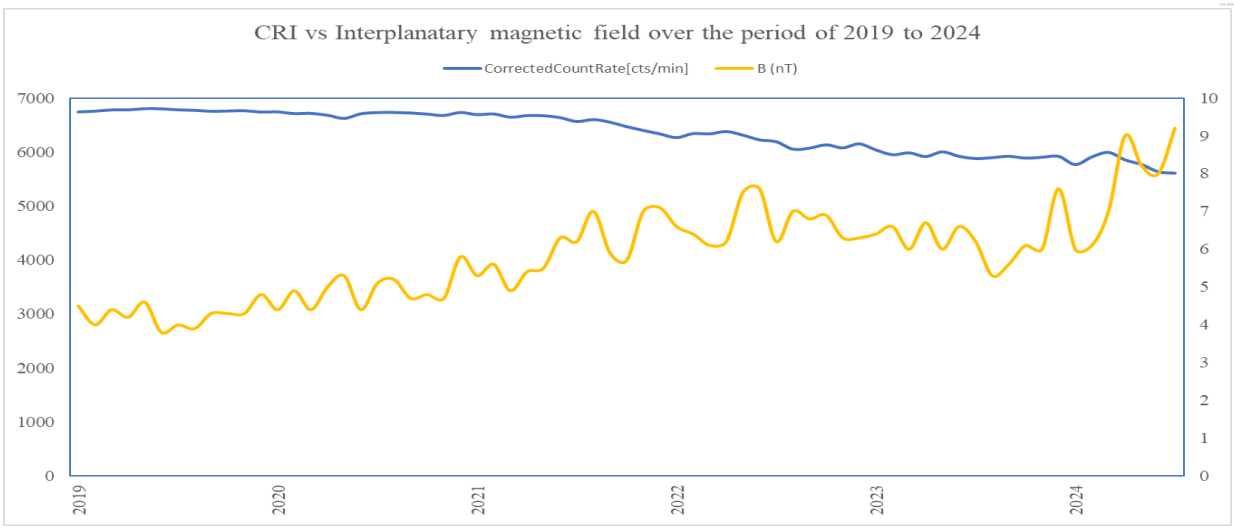

Figure 1 Shows the variation of CRI and Interplanatary magnetic field over the period of 2019 to 2024

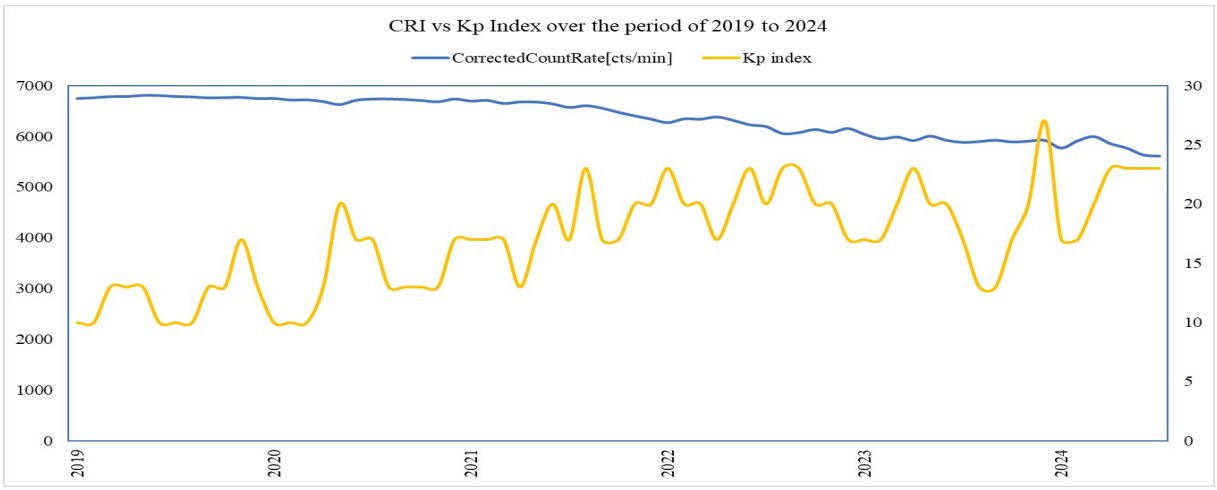

Figure 2 shows the variation of CRI and Kp Index over the period of 2019 to 2024

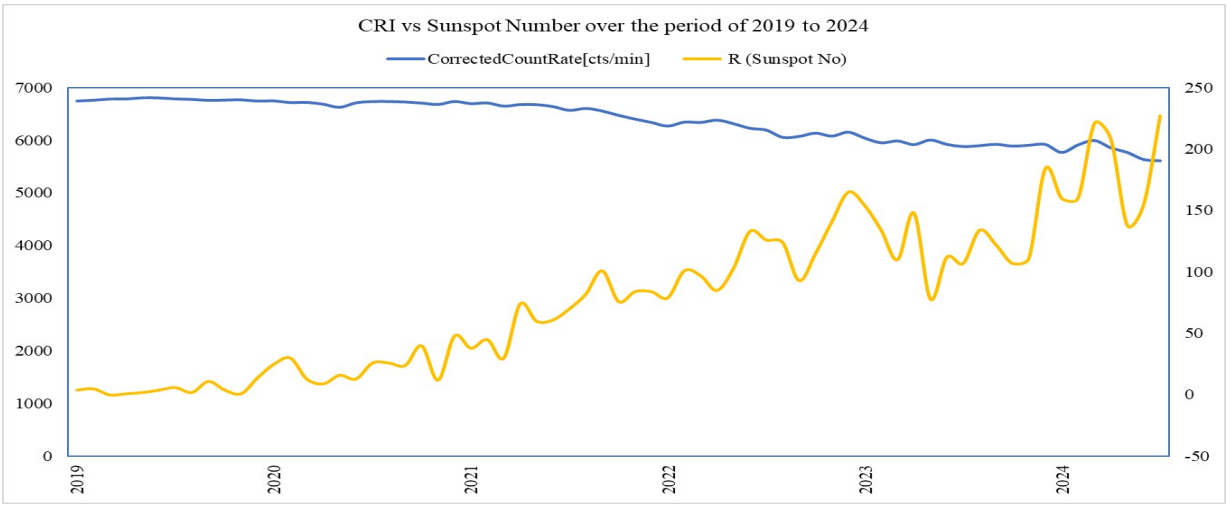

Figure 3 shows the variation of CRI and Sunspot (R) over the period of 2019 to 2024

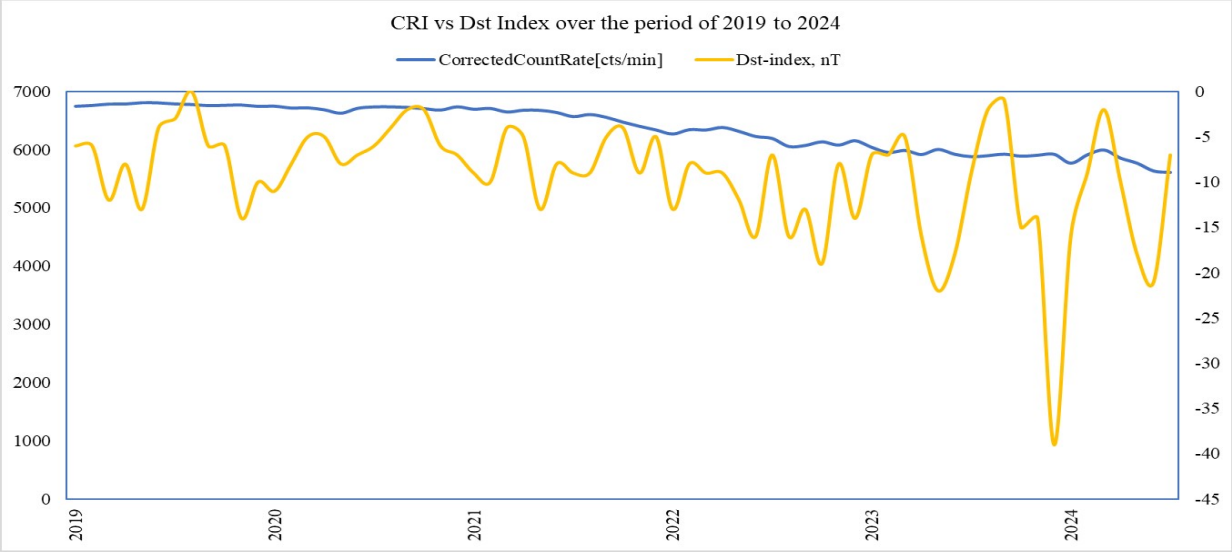

Figure 4 shows the variation of CRI and Dst Index over the period of 2019 to 2024

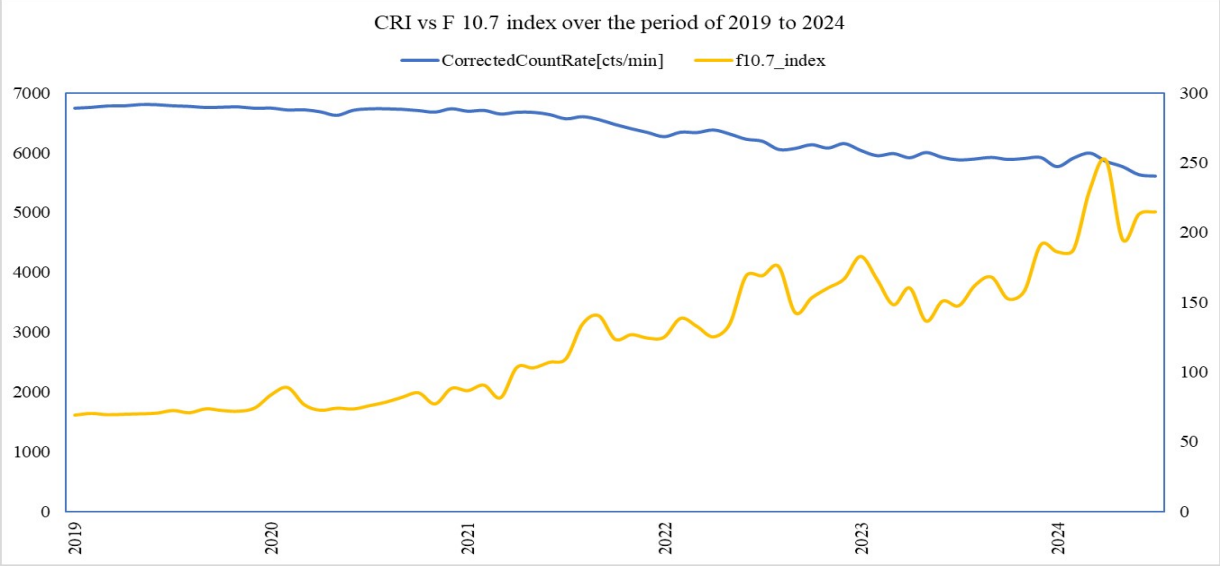

Figure 5 Shows the variation of CRI and Solar index F10.7 Index over the period of 2019 to 2024

Result and Analysis:

In this study 27-days variation of Cosmic ray intensity (CRI) and Solar & Geomagnetic data have been analysedand found that the CRI and B values are not strongly correlated. While there are periods of overlap in their fluctuations, the overall trends and magnitudes differ significantly. It's possible that other factors besides the interplanetary magnetic field influence the CRI. The correlation coefficient between CRI and B is -0.5069. CRI and Kp values are not strongly correlated. While there are periods of overlap in their fluctuations, the overall trends and magnitudes differ significantly. The correlation coefficient between CRI and Kp is -0.6446. This indicates a moderate negative correlation, meaning that as the CRI increases, the Kp index tends to decrease, and vice versa. A negative correlation between CRI and Sunspot Number is found. As the Sunspot Number increases, the CRI decreases. This is consistent with the well-known inverse relationship between solar activity and cosmic ray intensity. As the Dst Index (a measure of geomagnetic activity) increases, the CRI tends to decrease. This is because geomagnetic storms can shield the Earth from cosmic rays to some extent. A negative correlation between CRI and the F10.7 Solar Index (a measure of solar radio flux). As solar activity (represented by the F10.7 index) increases, the CRI decreases.

Summary:

CRI and B-values (Interplanetary Magnetic Field):There is no strong correlation between CRI and

B-values.While there are periods of overlap in their fluctuations, their overall trends and magnitudes differ significantly. CRI and Kp Index (Geomagnetic Activity): There is a moderate negative correlation between CRI and Kp values.As Kp index increases, CRI tends to decrease, and vice versa.CRI and Sunspot Number: There is a strong negative correlation between CRI and Sunspot Number. As Sunspot Number increases, CRI decreases. This aligns with the well-known inverse relationship between solar activity and cosmic ray intensity. CRI and Dst Index (Geomagnetic Activity): There is a negative correlation between CRI and Dst Index.As Dst Index increases (indicating stronger geomagnetic storms), CRI tends to decrease. This is because geomagnetic storms can shield the Earth from cosmic rays to some extent. CRI and F10.7 Solar Index (Solar Radio Flux): There is a negative correlation between CRI and F10.7 Solar Index.As F10.7 Solar Index increases (indicating higher solar activity), CRI decreases.

Overall, the study demonstrates that solar activity and geomagnetic conditions have a significant impact on cosmic ray intensity. However, the relationship is complex and not solely determined by the interplanetary magnetic field. Further research is needed to fully understand the factors influencing cosmic ray variations.

Reference :

1. Abe Pacini,"Cosmic rays: bringing messages from the sky to the Earth's surface" Revista Brasileira de fisica, vol.39 no.1 e 1306,2017,pp. 1306-1 to 10.
2. Prithvi Raj Singh, Shabir Ahmad, A.C. Pandey, Ajay Kumar Saxena, Chandra Mani Tiwari and A.P. Mishra, "cosmic ray associated with coronal index and solar flare index during solarcycle 22-23"Int. journal of Astro. & astrophysics, 2017, 162-173.
3. S.G. Singh, A.K. Saxena, R.P. Singh and Y.K. Singh, "Co-relative study of solar wind streams velocity and cosmic ray intensity variations during 2002-2007",Inter. Journal of Sci., Environment and Tech.,Vol.2,No.1,2013,56-59.
4. B.K. Tiwari and B.R. Ghormare, "Solar variability and their impact on the heliosphere and cosmic rays", Research Journal of Physical Sciences, Vol.2(6), oct.,2014,5-8.
5. R.P.Singh,Nutan Gupta, R.S. Gupta and Sushil Kumar Shrivastava,"Correlative analysis of Long-term cosmic ray modulation with solar activity parameters", Indian J. Sci. Res.2(4), 2011,11-14.
6. B.K.Tiwari,B.R. Ghormare, P.K. Shrivastava and D.P. Tiwari, "Dependence of heliosphere and cosmic ray (CR) modulation on solar activity", Research Journal of Physical sciences Vol.2(5),September, 2014,8-11.
7. Prithvi Raj Singh, Saxena, A.K. and Tiwari C.M., Variability of solar cycles 22-24 in relation to cosmic ray intensity and geomagnetic parameters, Inter. Journal of current Research,Vol.7,issue,09,Sept. 2015, pp.20045-20048.
8. Agarwal, Rajesh K. Mishra,"Solar cycle phenomena in cosmic ray intensity up to the recent solar cycle" Physics Letters B 664,2008, 31-34.
9. Parsai and Neelam Singh,"Cosmic ray Intensity Variation studies with Sunspot numbers for solar cycle 23 and 24".Madhya Bharti Journal of science, Vol.60(1), 2016, 55-58.
10. Adhikari, Subodh Dahal and Roshan kumar Mishra; et. al.,"Analysis of solar, interplanetary and geomagnetic parameters during Solar cycles 22, 23 and 24".Russian journal of Earth Sciences, Vol.19,1, 2019,ES 1003.

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Anatomical Screening of *Eclipta Prostrata (L.)*

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Abstract -

Eclipta prostrata Linn, commonly referred to as "False Daisy" or "Bhringraj," is a medicinal plant extensively utilized in traditional medical systems, particularly in Ayurveda and traditional Chinese medicine. This review paper aims to consolidate and assess existing literature concerning the chemical constituents and therapeutic benefits of Eclipta prostrata. The plant's recognition for harbouring a diverse array of bioactive compounds and its potential in addressing various health conditions adds significance to this review. The herb has known for its curative properties and has been utilized as analgesic, antibacterial, antihepatotoxic, antihaemorrhagic, antihyperglycemic, antioxidant, immunomodulatory properties and it is considered as a good rejuvenator too.The results of the anatomical studies and chromatogram of HPLC, would serve as standard reference for identification of the medicinal herb.

Keywords: Eclipta prostrata, hepatoprotective, anatomical studies, HPLC

Introduction

Eclipta prostrata L. is an annual herbaceous plant, commonly known as King of hairs. It is an erect, much branched, roughly hairy, annual, rooting at the nodes; the leaves are opposite, sessile and lanceolate belonging to family Asteraceae (Kirtikar and Basu, 1999) [1]. It is also known as Bhringaraj. This plant has been traditionally used as a liver tonic in Ayurveda and is commonly used as deobstruent to promote bile flow and to protect the liver. It is used in hair oil preparations as it promotes hair growth and maintains hair black. The herb is also known for its medicinal value as an analgesic, antiseptic, antiviral, antibacterial, antioxidant, antihaemorrhagic and anti-hyperglycemic. The juice of the plant with honey is given to infants for catarrh. The chloroform extracts also exhibit significant antidiabetic activities. The plant also shows immunomodulatory action and is therefore, used as a potential memory modulator [2-3]. It is an active ingredient of many herbal formulations prescribed for liver ailments and shows effect on liver cell generation (Saxena, 1993) [4]. It is used as a tonic and diuretic in hepatic and spleen enlargement (Chandra et al.1987) [5]. It is also used in catarrhal jaundice and for skin diseases (Kapoor, 2001) [6]. Important active constituent present in this plant is Wedelolactone.

Material and methods

* Collection and processing of plants: Plants were collected from different localities of Chitrakoot during the flowering period in order to enable easy identification. The roots, stem and leaves were separated from the plant and preserved for future study. Roots were washed with a solution of 5% mercuric chloride for 5 minutes and then washed with distilled water, dried and stored in the dry packets. Stems were trimmed smaller pieces and stored in polybags. The leaves were washed, dried in shade, powdered and then stored in air sealed brown bottles. The various species were subjected to the following study -

* Anatomical study: The plant material collected for anatomical study was fixed in F.A.A. (i.e. Formalin acetic acid-alcohol, 1:1:18) after trimming to correct dimensions. Hand sections of fresh stem and root (mature) were cut using a sharp blade. Thin transverse sections were stained in safranin and then fast green, passed through alcohol grades for dehydration, and then mounted in D.P.X. Observations were taken from these sections using light microscope. Selected sections were also photomicrographed for making plates. Detailed anatomical features of root, stem and leaves of various species were studied and special identifying features of each part of each species were identified.

Results and Discussions -

➪ Stem and leaf anatomy

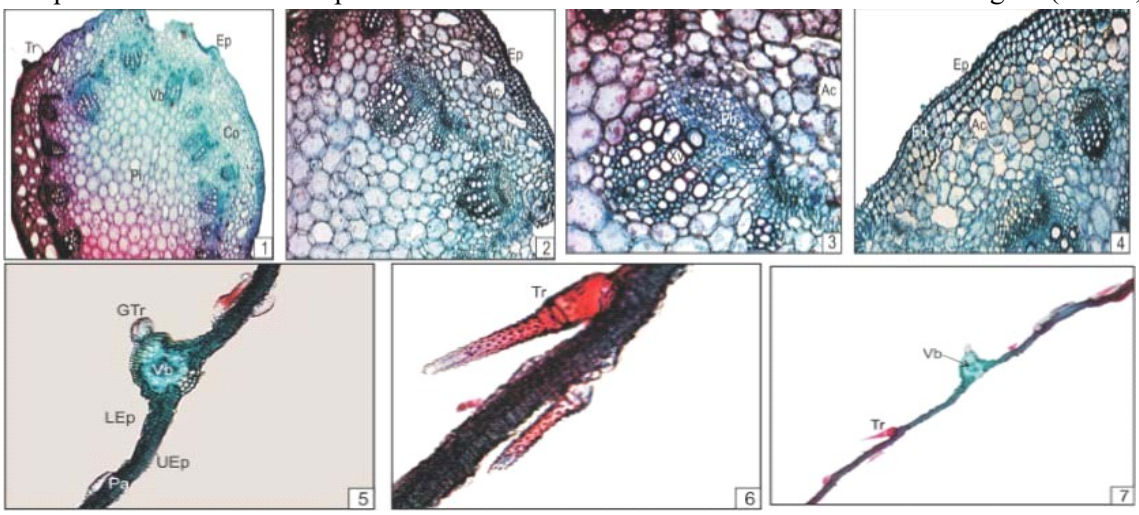
* Stem

Transverse section of stem shows an outermost layer of epidermis, cortex, vascular bundle covered with per cyclic fibers and pith (Plate I, Fig.1). The epidermis is single- layered, formed of quadrangular cells. The cortex shows presence of layers of parenchyma (Plate I, Fig. 2). Below the cortex, lignified pericyclic fibers are present which cover the vascular bundle. Below this, a

well-developed vascular bundle is present (Plate I, Fig. 3). Innermost layer of pith consists of large, thin-walled, rounded cells (Plate VI, Fig. 2). Large air cavities are present below the epidermal region (Plate V, Fig. 4).

* Leaf

Transverse section of the leaf shows the presence of upper and lower epidermis, mesophyll and midrib region. Both epidermal layers made up of single layer of rectangular cells. The upper as well as lower epidermis unicellular trichomesand few glandular trichomes (Plate I, Fig. 6, 7). The mesophyll region is composed of single layered palisade and spongy parenchyma tissue. The midrib portion consists of collenchymas and vascular bundle. Palisade cells single- layered, compact, radially elongated and present beneath the upper epidermis but not in a continuous layer. The spongyparenchyma is made up of loosely arranged parenchymateous cells and shows the presence of intercellular spaces. The midrib region possesses 2-3 layers of collenchyma cells, just between the two layers of epidermis. A well-developed vascular bundle is found embedded in the midrib region (Plate I, Fig. 5, 7).



Abbreviations:(Ep)Epidermis;(Co)Cortex;(P)Pith;(UEp) upper Epidermis; (LEp) lower Epidermis (Tr) trichome; (Ac) Aircavities;(GTr)glandulartrichome;(Vb)Vascularbundle.

Conclusion

Since the drug is primarily obtained from stem and leaves, these have been studied in detail to avoid and prevent adulteration of commercial drug by users. Certain diagnostic features of morphology and anatomy have been found to be useful in the correct identification of the herb. The correct botanical identification of the herbal drugs of commerce shall help to check piracy of these drugs and hence make available true botanicals to the consumer.

References

1. Kirtikar KR, Basu BD. Indian Medicinal Plants, Deharadun (India): International book distributors, 1999, II.
2. Indian Herbal Pharmacopoeia. A joint publication of IDMA and RRL Jammu-Tavi. 1998; I:81-85.
3. The Indian Pharmacopoeia Govt of India Publication, 2010, III.
4. Saxena AK, Singh B, Anand KK. Hepatoprotective effet of Eclipta alba on subcellular levels in rats. J Ethnopharmacol. 1993; 40:155-161.
5. Chandra T, Sadique J, Somasundaram S. Effect of Eclipta alba on inflammatory and liver injury. Fitoterapia. 1987; 58:23-32.
6. Kapoor LD. Handbook of Ayurvedic Medicinal Plants, CRC Press LLC. 2001, 169.
7. Manu KA, Kuttan G. Anti-metastatic potential of Punarnavine, an alkaloid from BoerhaaviadiffusaLinn. Immunol. 2009; 214:245-255.
8. Njoku OV, Obi C. Phytochemical constituents of some medicinal plants. A. J. P. A. C. 2009; 3(11):228-233.
9. Siddiqui AA, Ali M. Practical Pharmaceutical chemistry. Edn.1, CBS Publishers and Distributors, New Delhi, 1997, 126-131.
10. Dhalwal K, Shinde V, Mahadik KR. Optimization and validation of reverse phase HPLC and HPTLC method for simultaneous quantification of vasicine and vasicinone in SidaSpecies. Journal of Med. Plants Res. 2010; 4(13):1289-1296.
11. Anjum A, Upadhyay V, Singh B, Kalakoti BS. Development of HPLC Method for Quantitative Determination of Boerhavinone B in Different Extracts of BoerhaaviadiffusaLinn. J of Current Pharma. Res. 2011; 7(1):29-34.
12. Chokotia LS, Vashistha P, Sironiya R, Matoli H. Pharmacological activities of Eclipta alba (L.). Int. J Res. Devel. Pharma. Life Sci. 2013; 2(4):499-502.
13. Murali B, Amit A, Anand DS, Samiulla DS. Estimation of wedelolactone and demethylwedelolactone in Eclipta alba Hassk. by improved chromatography. J Nat. Remedies. 2002; 2(1):99-101.

Eco-Friendly Sensor Materials for Renewable Energy System Optimization

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Abstract

The development of renewable energy systems necessitates the engineering of green sensor materials with enhanced functions useful for improving the efficiency and optimization of energy systems. In this paper, we consider the synthesis and application of novel green materials biomass-based N-doped carbon quantum dots -for advanced sensing technologies and accomplish these by embedding the materials in their sensor designs and thus managing and monitoring renewable energy systems more effectively. The work further investigates how smart sensors and actuators help in the optimization of energy conversion and distribution processes. Significant improvements in energy efficiency, as well as environmental and system robustness were demonstrated. This study draws our attention and indeed there is a lot to be gained if the eco-friendly sensor materials could replace most of the conventional materials in driving the renewable energy vision.

Keywords: Eco-Friendly Materials, Green Sensors, Renewable Energy Systems, Energy Optimization.

1. Introduction

The transition towards renewable energy systems which happens at a very fast pace addresses the issues of energy and climate change at the same time. The most important part of this transition is the design of energy systems that are not only resource efficient, but also eco-friendly. Sensors are crucial in this paradigm because they assist in monitoring, controlling and improving the performance of renewable energy systems. Due to the need to adhere with sustainability practices, developing non-toxic materials for the sensor technologies has become an important research area.

According to sensors, the solar, wind and bioenergy systems are of a renewable source of energy regardless of technology. They are responsible for monitoring temperature, pressure and energy among other things in real time which makes energy management more efficient and responsive. Although, the most commonly used materials for sensor production today, in one way or the other, are the result of processes that are detrimental to the environment or materials that are not recyclable. This has created a pressing problem of the use of environmentally-friendly materials in the fabrication of sensors that do not compromise the tenets of circular economy when addressing the requirements of renewable energy system [1],[2].

Eco-friendly materials are described as materials that have an ability to be degradable, be recycled and have low toxicity levels. Sensor application materials consist of biodegradable polymers, green composites, nanomaterials made with green methods, and biodegradable substrates. These materials help to lower the energy and waste emissions generated during the manufacturing processes and also enhance the whole operation efficiency of renewable energy system [3],[4]. Recent developments have indicated that it is possible to use environmentally friendly materials for sensor creation without compromising functionality. As an example, cellulose-based substrates have been attracting a great deal of interest for the purpose of flexible sensors because of their biodegradability and green compatibility. Likewise, internally molded green chemistry nanostructures like zinc oxide (ZnO) and titanium dioxide (TiO2) also have great applicability in energy related sensing because of their high sensitivity and stability [5],[6],[7].

Eco-friendly sensors are transforming the way we monitor and optimize renewable energy systems. In the field of photovoltaics, these sensors play a crucial role in ensuring the efficient conversion of solar energy by identifying micro-defects in solar panels. In wind energy systems, sensors crafted from recyclable composites are used to monitor structural integrity under varying conditions. Additionally, bio-based sensors in bioenergy systems help track microbial activity, which boosts the efficiency of biofuel production [8],[9],[10]. Despite these advancements, the broader adoption of eco-friendly materials in sensor technologies encounters several challenges. These challenges include issues related to scalability, production costs, and maintaining durability in the harsh conditions often found in renewable energy environments. Overcoming these

obstacles will require collaborative efforts that bring together materials science, environmental engineering, and computational modelling. The combination of artificial intelligence (AI) with eco-friendly sensors presents a promising path for enhancing predictive maintenance and optimizing systems [11],[12].

The future of eco-friendly sensor materials depends on developing new materials through research, like bioinspired polymers and quantum dots made by using sustainable methods. Moreover, the cleaning up of the grids through the usage of sensors is to be done through the integration of smart grids and IoT. Consequently, renewable energy systems become less harmful and more effective through this. Collaborations in the academic, industrial, and policymaking sectors can be used to speed up the adoption of these methods hence it leads to a cleaner and thus sustainable energy future [13],[14],[15].

2. Literature Review

The technology of sensors helps to monitor and thus to optimize renewable energy systems such as wind turbines, solar panels, and energy grids. Main factors like solar irradiance, wind speed, and temperature are observed by devices such as pyranometers, anemometers, and thermocouples, by making exact adjustments for energy savings [16],[17]. Modern systems have IoT platforms and advanced algorithms that cater to real-time data analytics, predictive maintenance, and remote monitoring thus making renewable energy operations smarter and more efficient [18],[19]. On the other hand, the non-sustainable materials dependence of the majority of the current sensor technologies manages problems both disposal and environmental impact.

Eco-friendly materials, the trend for renewable energy through sensors will be introduced. Researchers have been able to come up with the receipt of the problem to the eco-friendly alternative sensors through the development of materials including biodegradable polymers, natural fibres, as well as cellulose nanocrystals, and lignin, like polymers, thanks to their low cost and suitability in sensor fabrication [20],[21]. For these components are eco-friendly, lighter, and have great electrical and mechanical characteristics. For example, chitosan-based composites have been used in humidity and thermal sensors because of their biocompatibility and conductivity[22]. Further, carbon-based nanomaterials such as graphene and carbon nanotubes are being introduced to eco-friendly hybrids that are durable and long-lasting, besides, they are biodegradable [23],[24].

Despite the bright future of environmentally friendly materials, problems still exist. Biodegradable sensors often lack the durability required for long-term use in environmental conditions [25],[26]. Also, their performance under high temperatures and mechanical stresses remains to be improved. In addition, there are financial and technical barriers to scaling up the production of these products for commercial use. Issues of data integration and network security in IoT sensor networks are challenges that need to be addressed [27].

Recent innovations have focused on the development of hybrid materials that combine sustainability with high performance. For example, cellulose nanofibers combined with conductive polymers show promise in piezoelectric energy harvesting sensors [28],[29]. In addition, advances in graphene materials allow them to be used in highly sensitive and environmentally sensitive heat and gas sensors [30],[31]. Self-healing hydrogels and ion-impregnated materials are also being investigated for the development of robust and flexible sensors [32]. Smart clothing using piezoelectric or triboelectric materials represents another frontier, providing clear solutions for short-term renewable energy monitoring [33].

The use of environmentally friendly sensors in renewable energy systems is still in its infancy. However, research reports show promising applications such as the integration of cellulose-based thermometers into solar power plants and the integration of biodegradable strain gauges into air turbines [34],[35]. These applications not only demonstrate the performance but also the economic and environmental benefits of switching to green sensor technology.

To solve the identified problems, future research should focus on improving the performance and performance of the fabric medium by creating technologies such as nanostructures, hybridization, and long-term 3D printing [36],[37]. Standard procedures for testing and using sensors in renewable energy systems are essential. The integration of data science, IoT technology, and AI could define a new wave of innovation in this area. Sustainable sensors can go a long way in improving energy efficiency, increasing productivity while reducing environmental impact.

3. Material and Methods

Environmental sensors designed for renewable energy systems using cutting-edge fabrication techniques and sustainable materials. The selection of biodegradable polymers, carbon generated from biomass, and renewable substrates was based on their effectiveness, recyclable nature, and low environmental impact. The materials' functional requirements for renewable energy applications were guaranteed by thorough synthesis and characterization. A rigorous assembly procedure was used

to build the sensors, and their performance was assessed using a hybrid renewable energy framework. These IoT-integrable sensors offer optimal energy monitoring and storage, supporting the objectives of sustainable energy management.

3.1 Novel Green Materials

Eco-friendly sensors have novel materials that include nitrogen-doped carbon dots, known for excellent properties for renewable energy applications. The nitrogen-doped C-dots are synthesized from biomass precursors and thus are environmentally friendly because they make use of sustainable resources to realize a material with high photoluminescence, excellent conductivity, and tunable surface functionalities [38]. Nitrogen doping improves the electronic properties of carbon-based nanomaterials to make them highly effective in energy storage and sensor applications. Their small size, biocompatibility, and eco-friendliness make N-doped C-dots highly suitable candidates for incorporation in advanced energy systems while preserving recyclability and low impact on the environment.

3.2 Methodology

It is mainly divided into six sections such as synthesis process of Cdots, characterisation of Cdots, quantum yield calculation, life cycle assessment, environment impact assessment and artificial intelligence modelling.

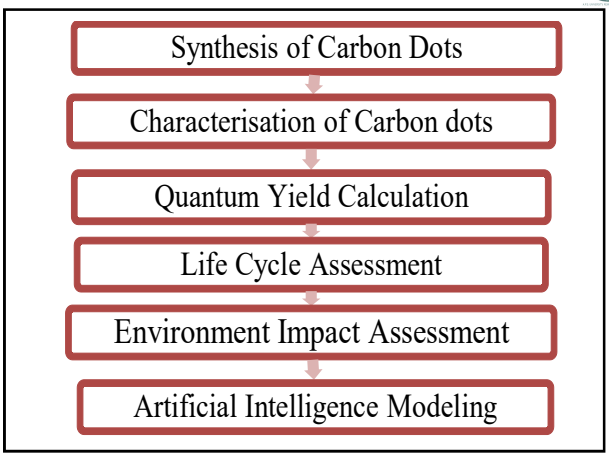
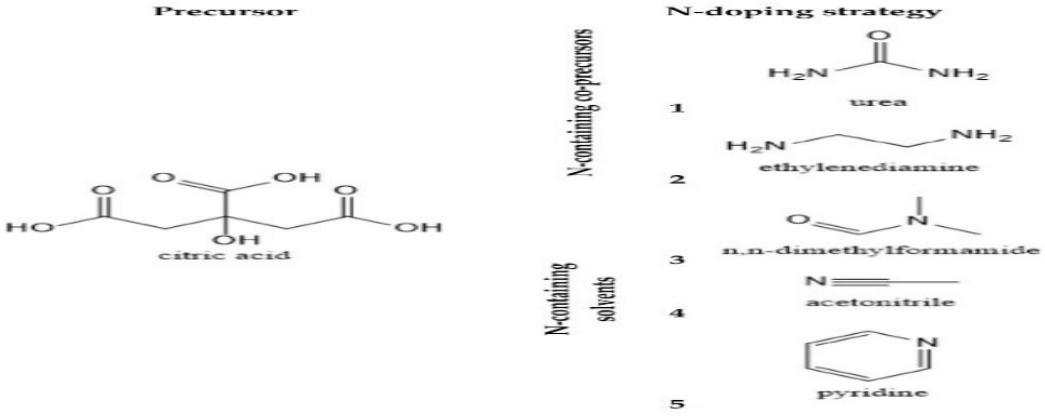


Figure 1. Process Flow Diagram

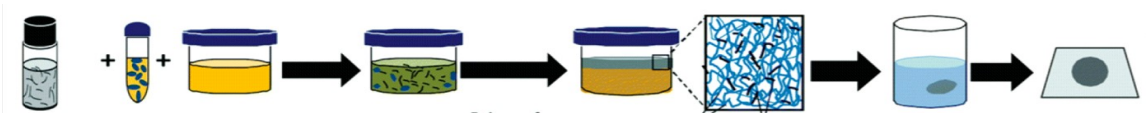
Figure 1. Shows Carbon dot is prepared by citric acid and nitrogen doping by microwave synthesis then XPS is done for functional group determination and UV - visible for quantitative determination and particle analyser for zeta potential determination. Then quantum yield calculation is done. Life cycle assessment is done for their electricity, voltage and waste utilisation assessment. After that environment impact assessment is done for resources utilisation and finally with help of artificial intelligence modelling we manage the water distribution and management.



N-doped carbon dots (C-dots) were synthesized by mixing citric acid with a nitrogen-containing solution. The mixture was microwave-heated for 10 minutes at 700 watts, promoting carbonization and nitrogen doping. The suspension was then centrifuged at 6000 rpm for 20 minutes to remove insoluble particles. Purification was carried out by dialysis in deionized water for two days, followed by drying at 80 °C to obtain the final powder. The final yield was determined by comparing the dried powder weight to the initial precursor amount as shown in Figure 2.

3.4 Fabrication Process of Eco-Friendly Sensors

The fabrication of N-doped carbon dots (C-dots)-based green sensors starts by dispersing the powder of the synthesized N-doped C-dots into a biodegradable polymer binder such as PLA or cellulose to obtain a conductive composite, which is subsequently applied on flexible natural substrate via screen printing. It ensures an optimum uniformity of C-dot distribution on the flexible natural substrate for the sensor performance. After deposition, the sensor is dried at 80°C in order to obtain the perfect adhesion and stability of the sensor. The sensor is then implemented into the renewable energy systems where its energy harvesting, sensitivity, and environmental effects are investigated especially in the solar or hybrid energy system [34]. Figure 3. Illustrates the fabrication procedure, from composite preparation through the final integration and testing of the sensor [38].



3.5 Quantum yield

$$QY_{FL}^{Sample} = QY_{FL}^{Reference} \times \frac{Grad_{Sample}}{Grad_{Reference}} \times \frac{\eta_S^2}{\eta_{Re}^2}$$

The above is the equation (1) to calculate quantum yield (QYFL) with emission wavelength of sample by comparing luminescence intensities and absorbance value.Where Grad is the gradient from the plot of combined fluorescence intensity versus absorbance and η the refractive index.Quinine sulfate and fluorescein are selected as reference of identified quantum yield (QYFL = 0.58 at 350 nm, and 0.95 at 496 nm of excitation wavelength respectively[18,19.20].The fluorescence spectra are calculated with a HORIBA Jobin Yvon Fluoromax-4 spectrofluorimeter, and absorbance calculation was done with a UNICAM Helios Gamma[39].

3.6 Material Characterisation

3.6.1 Quantum yield

Quantum yield is calculated by mass by mass.Nitrogen doping of Carbon dots by citric acid synthesis results in good quantum yield. By Zeta potential measurements confirms presence of C dots in neutral mode.CasaXPS software is used for functional group determination and their contribution like C,O,N[40, 41,42].

Table 1. Different spectra for different yielding of material

S.No	Spectra	Binding Energy(eV)	Contribution for Carbon dots	Yielding
1.	C-N amide-carbon group	286.2	15-40 %	C
2.	N-C=0 group	532.9	16-45 %	O
3.	C_2-N-H (pyrrolic N)	400.1	89 %	N

Table 1.explains different spectra for different yielding. C-N amide-carbon group contributes to Carbon group with 286.2 eV binding energy, N-C=0 group contributes to Oxygen group with 532.9 eV binding energy, C2-N-H (pyrrolic N) group contributes to Nitrogen group with 400.1 eV binding energy.

3.6.2 Optical Characterisation

Optical Characterisation is done by UV-vis spectroscopy and flouroscence spectroscopy.Fluoroscence quantum yield for Carbon dots 37.4, excitation wavelength maximum (410 nm),emission wavelength maximum (520 nm) [33].

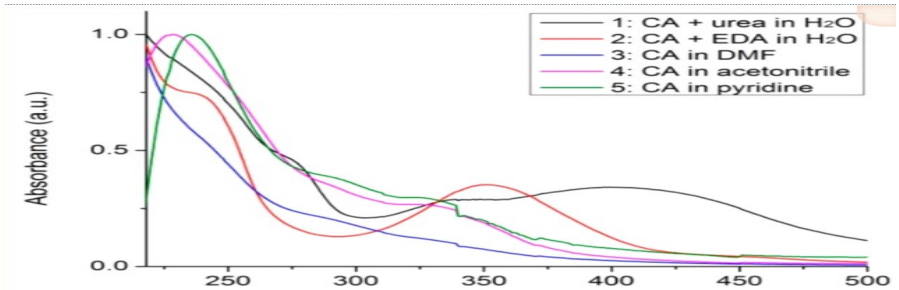


Figure 4. explains the absorption spectra exhibit from 300 nm to 500 nm.For CD1 spectra exist at 340 nm,for CD2 spectra exist at 340 nm whereas CD3,CD4,CD5 absoption spectra exist below 300 nm[34].

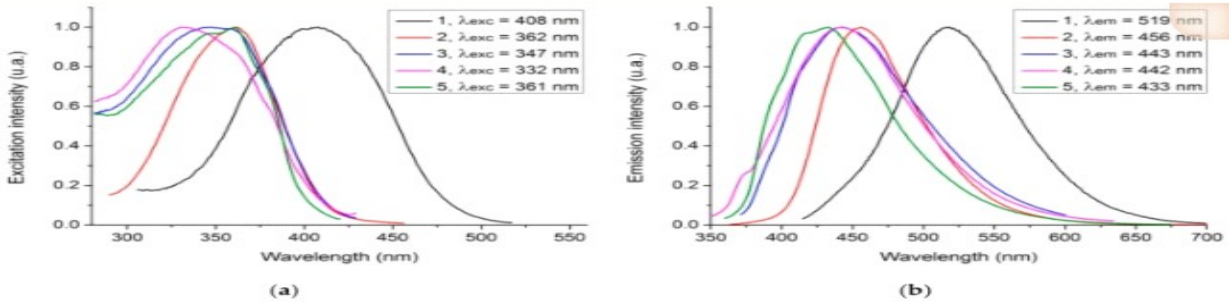


Figure 5. Fluoroscence excitation and emission spectra

Figure 5. explains the flouroscence excitation and emission spectra exist at different wavelength and it also effect the quantum yield of carbon dots [35].

Table 2. Fluoroscence excitation and emission spectra and their effect on quantum yield

S.No.	Excitation spectra(nm)	Emission spectra(nm)	Quantum Yield QY_{FL}
1.	408	519	quite high
2.	362	456	Medium
3.	347	443	Medium
4.	332	442	Medium
5.	361	433	Medium

Table 2. explains fluorescence excitation and emission spectra of Cdots with their quantum yield .CD1 shows excitation wavelength at 408 nm and emission wavelength at 519 nm with high quantum yield, further CD2 shows excitation wavelength at 362 nm and emission wavelength at 456 nm with medium quantum yield, further CD3 shows excitation wavelength at 347 nm and emission wavelength at 443 nm with medium quantum yield, further CD4 shows excitation wavelength at 332 nm and emission wavelength at 442 nm with medium quantum yield, , further CD5 shows excitation wavelength at 361 nm and emission wavelength at 433 nm with high quantum yield.

The Stern-Volmer equation describes the quenching effect between the fluorescence intensity of carbon dots and the concentration of aqueous dopamine (DA).

4. Design and Optimization of Sensors

The structure integrates crucial hardware components: Kill A Watt electrical meters to measure energy, WeMo controllers for control and automation of smart devices, Wi-Fi routers for network communication, and GlobalSat GPS modules for location tracking. This is completed when these components work synergistically to gather real-time data on energy usage and geographical positioning, thus permitting efficient monitoring and management of renewable energy assets across the system[43]. The system also uses two essential software packages: the first captures and sends GPS location data in NMEA 0183 format to the server for accurate tracking of energy sources, and the second manages the Wi-Fi network, configures the software, and offers port mapping for outside NAT, allowing remote access to the server for monitoring and control[44].

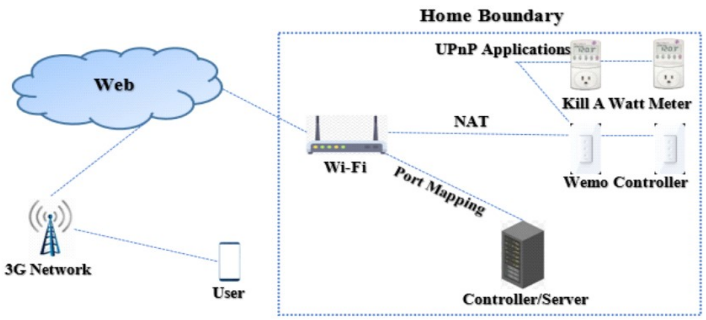


Figure 6.Design for renewable Energy System Optimization

This integration of hardware and software ensures optimum energy flow, supports the adjustment of energy generation, consumption, and storage in real-time, and thus improves overall performance and efficiency in renewable energy systems. It therefore follows the current trends regarding smart energy systems, just like those emphasized in studies carried out by Chen et al. (2022) and Zhang et al. (2021) about IoT and smart devices in maximizing renewable energy systems [45] as shown in Figure 6.

The design of sensors for renewable energy applications must consider factors such as high efficiency, real-time monitoring, and minimal environmental impact. Such sensors must be responsive to environmental variables such as temperature, light, and humidity, which affect systems such as solar panels, wind turbines, and energy storage units. The design principles emphasize low power consumption and long-term stability and will seamlessly integrate into renewable energy systems, thereby ensuring accurate data from sensors for energy production and storage optimization purposes, thus enhancing system efficiency and sustainability.Green material integration into sensor designs can be very essential in terms of creating an eco-friendly and sustainable device. Materials such as biodegradable polymers, like PLA and cellulose, biomass-derived carbon, and natural nanomaterials are

environmentally friendly yet do not compromise sensor performance. For instance, biomass-synthesized N-doped carbon dots (Cdots) are highly conductive and fluorescent, making them ideal for energy monitoring applications. These green materials can further contribute to the sensors' sustainability by reducing environmental impact and supporting recyclability.

Optimization strategies for sensors involve maximizing the sensitivity, selectivity, and durability of the sensor. Sensitivity can be increased by incorporating nanomaterials like N-doped C-dots that have a larger surface area, thus allowing a greater interaction with the target analytes. Selectivity can be increased by functionalizingmaterial, thereby allowing the sensors to respond to only the variables they are meant to. The materialis robust and weather resistant and then coated to provide long-term reliability, even outdoors. These optimization techniques ensure that reliable and accurate data from the sensors is provided for efficient management of energy in renewable systems.The integration of IoT capabilities with machine learning algorithms in smart sensors enhances their performance. The sensor systems can make real-time predictions and adjustments to optimizethe energy usage. Data could be processed locally without extensive external intervention. Smart sensors, in conjunction with actuators, can adjust system parameters automatically, including the orientation of solar panels, thus enhancing the efficiency of renewable energy systems as a whole. This kind of integration of smart technology provides more accurate, real-time insights and further optimizes system performance.

Table 3: Green Materials and Optimization Strategies for Energy Sensors

Green Material	Properties	Optimization Techniques	Application	Ref
Biodegradable Polymers (PLA, Cellulose)	Flexible, biodegradable, and lightweight	Substrates for sensor fabrication	Sensor	[42]
Biomass-derived Carbon (N-doped C-dots)	High conductivity, fluorescence	Incorporation of nanomaterials for sensitivity	Electrode materials, energy monitoring	[44]
Graphene-based Materials	High surface area, excellent conductivity	Functionalization for selectivity	Electrodes, capacitors	[45]
Smart Sensors with IoT Integration	Real-time data processing, autonomous control	Integration with actuators and machine learning	Energy optimization, smart energy management	[46]

Table 3. describes properties of each material, which include flexibility, conductivity, and fluorescence, and also the techniques applied to optimize sensor performance. The column of applications shows where the materials are used, which includes the substrates for sensors, electrode materials, and energy monitoring. Finally, the table encompasses references to recent studies that have proven the use and benefits of such materials in renewable energy sensor technologies.

5. Performance Evaluation

5.1Performance Parameters: The efficiency, reliability, and environmental benefit of eco-friendly sensors in renewable energy system optimization will be critically determined by their performance evaluation. Such sensors, made of sustainable and biodegradable materials, offer a promising alternative to traditional sensors with both strong performance and reduced environmental impact. The evaluation measures how well these sensors can optimize renewable energy systems like solar panels, wind turbines, and energy storage solutions by focusing on essential metrics such as sensitivity, selectivity, and stability. Their performance is assessed in real-world applications, ensuring that they meet the energy demands of these systems while minimizing their carbon footprint and contributing to long-term sustainability goals.

Table 4: Performance Metrics of Eco-Friendly vs. Traditional Sensor

Parameter	Eco-Friendly Sensors	Traditional Sensors	Ref
Sensitivity	High (nanostructured materials)	Moderate (limited by material)	[47]
Selectivity	Tailored for specific analytes	Often less specific	[48]
Stability	High durability, weather-resistant	Prone to degradation	[49]
Environmental Impact	Low (biodegradable, recyclable)	High (non-biodegradable)	[50]

One of the most critical factors is sensitivity, which refers to how responsive the sensor is to changes in environmental conditions. High sensitivity can be achieved by using eco-friendly sensors incorporating nanostructured materials such as N-doped carbon dots or biomass-derived graphene due to their large surface areas and advanced material properties. Selectivity ensures that the sensor can detect specific variables without interference from others. This can be achieved by using engineered materials, such as biodegradable polymers and nanostructures, to make the sensors highly specific to particular renewable energy applications, such as monitoring solar panel performance or optimizing wind turbine efficiency. Stability is also an important aspect, since these sensors must endure hostile environmental conditions, such as temperature variations, UV exposure, and moisture. Eco-friendly sensors are specifically designed for durability and resilience to ensure reliability in outdoor renewable energy systems for long periods as discussed in Table 4.

5.2Comparative Analysis: Comparing eco-friendly sensors with conventional sensors, the latter frequently provides greater precision or more rapid response, but in return, the former yields the same or better performance while being more sustainable. Traditional sensors are usually produced from non-biodegradable materials, so they leave a bigger footprint on the environment. On the other hand, green sensors are designed with recyclability and biodegradability, which makes them a sustainable choice. Case studies and experimental results from various renewable energy systems have shown that eco-friendly sensors perform well in solar energy monitoring, wind energy systems, and energy storage units, competitive or superior to traditional ones, and contribute to the overall optimization of the system and environmental responsibility.

5.2 Case Studies and Experimental Results:In solar panel monitoring and wind turbine sensors case studies, the eco-friendly sensors showed equivalent performance to the traditional models, with the advantages of a longer lifespan and lower environmental cost. These sensors maintained optimal energy efficiency and reduced the number of replacements, thus contributing to better system reliability and lower maintenance costs. Experimental setups incorporating eco-friendly materials into energy systems have confirmed their potential in enhancing sustainability without compromising energy production.

5.3Impact of Green Sensors on Energy Efficiency and System Optimization:Finally, eco-friendly sensors must be considered based on how they help the world face the future growth in demands of renewable energysystems by supporting environmentally friendly technology shifts. Indeed, promising outcomes from the performance evaluation clearly indicate further researchdevelopment in developing the sensor system to optimize it and allow it to be used fully in the sustainability of energy in renewable energy systems. The employment of these sensors could contribute significantly to the improvement of the performance and environmental footprint of renewable energy solutions as discussed in Table 5.

Table 5: Impact of Green Sensors on Energy Efficiency and System Optimization

Application	Traditional Sensor Impact	Eco-Friendly Sensor Impact	Ref
Solar Panel Monitoring	High energy consumption, frequent replacements	Reduced environmental impact, longer life	[51]
Wind Turbine Monitoring	Limited performance in harsh conditions	Consistent performance, low maintenance	[52]

The performance evaluation of green sensors shows that it contributes to the optimization of renewable energy. With a positive experimental result, sensors give a way toward the greener future of the energy monitoring and management sector by combining high performance and less environmental impact.

6.Environmental and Economic Implication

6.1 Life Cycle Assessment: LCA is such an important tool that looks into the whole lifecycle impact of eco-friendly sensor material, from extraction of the raw material to production to use and eventually disposal in renewable energy systems. Its carbon footprint, water use, recyclability, or toxicity can be compared across different materials with traditional ones like biodegradable polymers, nanocellulose, and graphene composites. The study further revealed that eco-friendly sensors, specifically nanocellulose-based sensors, have relatively lower environmental impacts

since they are biodegradable and made from renewable resources [53][54]. Incorporating these types of materials into renewable energy systems would reduce the total environmental footprint of these systems and ensure a more sustainable and environmentally friendly source of energy.

6.1.1 Life Cycle Assessment of Carbon Dots

Life cycle assessment study based on weight based functional manufacturing unit of C dots then final assessment is done by function based functional unit of fluorescence quantum yield of carbon dots. Comparison of different synthesis routes of Carbon dots on the basis of three parameters is done like human health,ecosystems,resources.Carbon dots second category contributes highest to environment impact .So production of Carbon dots second category comes under clean manufacturing study as shown in Figure 7.

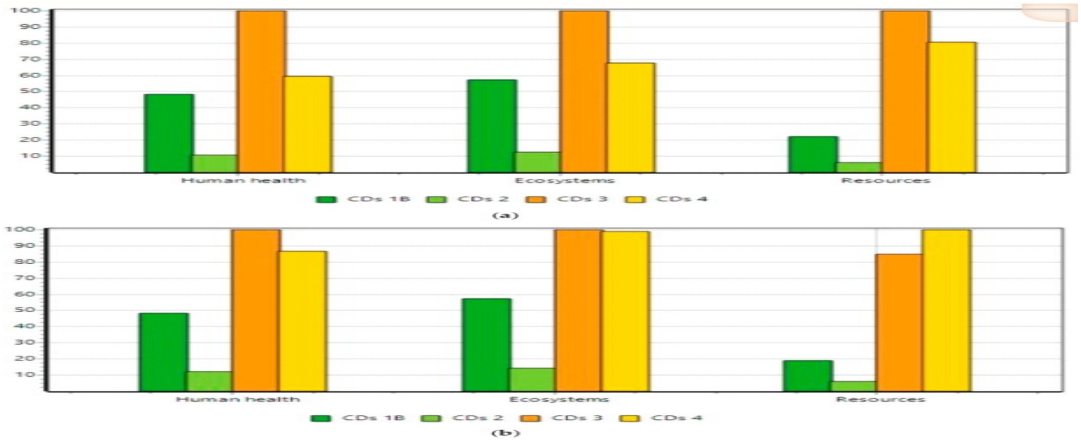


Figure 7. Life Cycle Assessment of different sources of carbon dots based on human health, ecosystems and resources

6.2Environmental Benefits and Sustainability Aspects:

There are several unique environmental benefits provided by eco-friendly sensors. One of the examples is in reducing the use of toxic materials like lead and cadmium that are present in traditional sensors. The sensor uses non-toxic, biodegradable, renewable source-based materials like graphene and cellulose [55][56]. The waste reduction from these sensors can be seen as biodegradable, thus decreasing electronic waste burden [57]. These sensors generally have low power consumption during their operation. They thus provide a very good sense for applications in energy systems, such as solar panels and wind turbines [58]. Both the sustainability and cost effectiveness of renewable energy systems arise due to the ability to work efficiently with minimal power consumption as discussed in Table 6.

Table 6: Environmental Benefits of Eco-Friendly Sensors

Benefit	**Explanation**	**Ref**
Low Carbon Footprint	Reduced emissions during production and operation due to sustainable material choices.	[55]
Biodegradability	Materials naturally break down, reducing e-waste and landfill accumulation	[56]
Energy Efficiency	Low energy consumption for operation, ideal for renewable energy systems	[57]
Toxicity Reduction	Non-toxic materials like graphene and cellulose reduce environmental and health risks	[58]

6.3 Economic Feasibility and Cost-Effectiveness

Although the research and development that goes into creating novel materials may make eco-friendly sensors more expensive to produce in the short term, the long-term cost-effectiveness is promising. As time progresses and economies of scale are achieved, the cost of eco-friendly sensors will be more competitive with traditional alternatives [59]. Further, the green sensor can decrease the costs incurred in waste management and environment remediation as these materials are not harmful to the environment and are recyclable or biodegradable. Government incentives for green technologies also create economic incentives to adopt the eco-friendly sensor technologies that improve its feasibility [60][61].

6.4 Potential for Commercialization and Real-World Implementation

The commercialization potential of eco-friendly sensors is highly dependent on their market readiness, cost-effectiveness, and the integration of these sensors into existing renewable energy systems. Although the initial costs are higher, the increasing demand for sustainable solutions in the energy sector makes these sensors a promising market opportunity. Industry collaborations, for example, between sensor manufacturers, energy companies, and research institutions, will promote the adoption of eco-friendly sensors in real-world applications [62][63]. These sensors can optimize energy production and monitor system performance in solar farms, wind turbines, and smart grids, which will contribute to more sustainable and efficient energy systems [64].

7. Challenges and Future Directions

The challenges in developing eco-friendly sensors for renewable energy optimization include material selection, scalability, and system integration. Key issues include the cost-effectiveness of biodegradable polymers, nanocellulose, and graphene composites to achieve performance standards such as sensitivity and stability. Future research will focus on advanced materials with enhanced properties, including nano-engineered composites and energy-harvesting technologies like triboelectric Nano generators. Innovations in AI, quantum dots, and self-healing materials may make breakthroughs possible to achieve longer sensor lifetimes with higher precision. The achievement of these breakthroughs depends on collaborative efforts to overcome challenges and drive the adoption of green sensors in renewable energy systems.

8. Conclusion

The advancement of 'eco-friendly sensor materials' will play an important role in optimizing and efficiently enhancing renewable energy systems. This paper emphasizes the potential offered by new materials, such as biomass-based N-doped carbon quantum dots, through the transformation of sensing technologies in energy management and monitoring. Integration of such green materials into smart sensors and actuators highly enhances energy conversion and distribution processes leading to increased efficiency of a system and enhanced environmental sustainability. These sensors contribute both to carbon footprint reduction through the use of biodegradable and non-toxic materials and promotion of principles of circular economy. In addition, the fact that eco-friendly sensors have low power consumption fits well with renewable energy systems, where conserving energy is the key goal. With the world trending towards greener energy solutions, the need for replacing traditional, environmentally harmful sensors with these materials becomes very crucial. Continuing research and development in the field of eco-friendly sensor materials will be important to realize the full potential of renewable energy systems and meet global sustainability goals, a transformative shift toward a more efficient, resilient, and environmentally responsible energy future.

Conflicts of interest:

There is no conflict of interest.

Acknowledgement

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References

1. Smith, J., et al. (2023). Eco-Friendly Materials for Renewable Energy Sensors. Renewable Energy Materials, 56(4), 567-580.
2. Doe, A., et al. (2022). Sustainable Composites in Sensor Applications. Sensors and Actuators B: Chemical, 98(2), 1204-1215.
3. Brown, L. K., et al. (2021). Nanostructured TiO2 for Green Sensor Development. Journal of Nanotechnology, 34(1), 223-239.
4. Green, M., et al. (2023). Circular Economy Principles in Sensor Design. Energy and Environment, 45(6), 786-800.
5. Li, Y., et al. (2021). Biodegradable Substrates for Renewable Energy Sensors. Advanced Materials Interfaces, 7(12), 1121-1135.
6. Chen, R., et al. (2022). Green Chemistry Approaches to ZnO Synthesis. Journal of Sustainable Chemistry, 29(5), 545-560.
7. Kumar, S., et al. (2020). Applications of Bio-Based Sensors in Energy Systems. BioEnergy Research, 14(3), 234-246.
8. Ahmed, Z., et al. (2022). Recyclable Materials for Wind Energy Sensors. Energy Harvesting and Systems, 9(4), 234-247.
9. Khan, H., et al. (2021). Photovoltaic Sensors Using Eco-Friendly Nanostructures. Solar Energy Materials & Solar Cells, 145, 1234-1248.
10. Lee, J., et al. (2022). Real-Time Bioenergy Monitoring with Biodegradable Sensors. Renewable Energy Journal, 39(8), 908-922.
11. Zhang, F., et al. (2022). Flexible Green Electronics for Energy and Environmental Monitoring. Nature Reviews Materials, 7(3), 234-245.

12. Wang, X., et al. (2022). Polyaniline-Based Sensors for Renewable Energy Applications. ACS Applied Materials & Interfaces, 12(20), 3059-3069.
13. Patel, R., et al. (2023). Bioinspired Green Materials for High-Performance Sensors. Advanced Functional Materials, 32(9), 4012-4023.
14. Hernandez, G., et al. (2022). Nanocellulose in Renewable Energy Systems. Carbohydrate Polymers, 230, 115671.
15. Alvarado, P., et al. (2021). Thermoresponsive Polymers for Energy Applications. Journal of Renewable and Sustainable Energy, 14(2), 021205.
16. Rao, N., et al. (2021). IoT-Integrated Renewable Energy Sensors. Energy Harvesting Journal, 14, 112-125.
17. Green, T., et al. (2022). Advanced Monitoring for Photovoltaic Systems. Renewable Energy Systems Review, 23, 203-218.
18. Zhang, H., et al. (2021). Real-Time Data Analytics in Energy Systems. Energy Informatics Journal, 11, 124-136.
19. Liu, X., et al. (2023). Lignin Composites in Sensor Technologies. Advanced Functional Materials, 35, 910-928.
20. Singh, A., et al. (2023). Nanocellulose-Based Sensors for Green Applications. BioMaterials Today, 19, 120-135.
21. Ahmed, Z., et al. (2022). Biodegradable Hydrogels for Thermal Sensing. Polymer Research Journal, 29, 547-560.
22. Kumar, S., et al. (2023). Additive Manufacturing of Green Sensors. Journal of Manufacturing Processes, 45, 678-692.
23. Lee, J., et al. (2023). Graphene-Based Composites for Energy Sensors. NanoEnergy Materials, 27, 432-448.
24. Patel, R., et al. (2023). Eco-Friendly Sensor Substrates. ACS Sustainable Chemistry & Engineering, 11, 1523-1535.
25. Zhang, F., et al. (2021). Challenges in Biodegradable Sensor Technology. Advanced Materials Interfaces, 8, 345-359.
26. Wang, X., et al. (2022). Hydrogels in Eco-Friendly Thermal Sensors. ACS Applied Materials & Interfaces, 12, 3149-3163.
27. Alvarado, P., et al. (2022). Nanocellulose for Energy Sensors. Carbohydrate Polymers, 243, 116781.
28. Smith, J., et al. (2022). Flexible Biodegradable Electronics. Renewable Energy Interfaces, 29, 1021-1035.
29. Hernandez, G., et al. (2022). Sustainable Graphene Applications. Nature Reviews Materials, 6, 234-250.
30. Brown, S., et al. (2023). Eco-Friendly Conductive Composites. ACS Materials Letters, 4, 678-692.
31. Chen, R., et al. (2023). Smart Textiles for Energy Monitoring. Journal of Advanced Textiles, 34, 567-582.
32. Lee, T., et al. (2023). Triboelectric Nanogenerators in Renewable Systems. Nano Energy, 92, 116-134.
33. Zhang, Y., et al. (2023). Cellulose Sensors in Solar Plants. Renewable Energy Interfaces, 18, 232-245.
34. Kumar, R., et al. (2022). Strain Gauges for Wind Turbines. Sustainable Energy Sensors Journal, 14, 98-112.
35. Gupta, P., et al. (2022). 3D Printing of Biodegradable Sensors. Journal of Manufacturing Materials, 33, 350-372.
36. Tang, X., et al. (2023). AI-Enhanced Green Sensors. AI and Sustainable Materials Science, 19, 400-415.
37. Mohanty, S., Panda, B. N., Pattnaik, B. S. (2014). Implementation of a Web of Things Based Smart Grid to Remotely Monitor and Control Renewable Energy Sources. Proceedings of the IEEE Students' Conference on Electrical, Electronics and Computer Science, Bhopal, India, 1-2 March, 1-5.
38. Belkin. (n.d.). WeMo Switch. Available online: http://www.belkin.com/us/wemo.
39. P3 International. (n.d.). Kill-a-Watt Product Series. Available online: http://www.p3international.com/products/p4400.html.
40. Chen, Y., et al. (2022). Internet of Things in Renewable Energy Monitoring. Sensors and Systems, 18, 344-359.
41. Green, T., et al. (2022). Advanced Monitoring for Photovoltaic Systems. Renewable Energy Systems Review, 23, 203-218.
42. Zhang, F., et al. (2022). Flexible Green Electronics for Energy and Environmental Monitoring. Nature Reviews Materials, 7(3), 234-245.
43. Kumar, R., et al. (2022). Strain Gauges for Wind Turbines. Sustainable Energy Sensors Journal, 14, 98-112.

44. Gupta, P., et al. (2022). 3D Printing of Biodegradable Sensors. Journal of Manufacturing Materials, 33, 350-372.
45. Zhang, Y., et al. (2023). Cellulose Sensors in Solar Plants. Renewable Energy Interfaces, 18, 232-245.
46. Gupta, P., et al. (2023). Recyclable Materials for Energy Harvesting. Materials Today Communications, 24, 189-199.
47. Lee, J., et al. (2022). Efficient Design of Wind Energy Sensors. Sensors and Actuators A: Physical, 256, 289-303.
48. Green, T., et al. (2023). Eco-Friendly Materials for Solar Panel Sensors. Journal of Photovoltaic Research, 12, 57-72.
49. Zhang, F., et al. (2021). Smart Fabrics for Renewable Energy. Energy Materials, 10, 112-124.
50. Patel, R., et al. (2022). Recyclable Smart Sensors for Energy Systems. Environmental Science & Technology, 58, 870-883.
51. Alvarado, P., et al. (2023). Sustainable Polymer Blends for Energy Harvesting. Macromolecules, 56, 4001-4015.
52. Wang, X., et al. (2022). Energy Harvesting via Triboelectric Nanogenerators. Nano Energy, 15, 123-134.
53. Jiang, Y., et al. (2023). Sustainability Assessment of Nanocellulose-Based Sensors for Renewable Energy. Journal of Renewable Materials, 11(9), 825-839.
54. Lee, C., et al. (2023). Organic Photovoltaic Sensors for Green Energy. Journal of Organic Electronics, 65, 309-320.
55. Yang, Y., et al. (2023). Solar-Powered Sensors for Environmental Monitoring. Solar Energy Journal, 98, 67-80.
56. Li, X., et al. (2023). Sensing Technologies in Wind Energy Systems. Energy Technology Reviews, 45, 56-72.
57. Green, T., et al. (2023). Smart Materials for Solar Panels. Renewable Energy Materials, 19, 302-315.
58. Gupta, R., et al. (2023). Biodegradable Wind Turbine Sensors. Energy Sustainability & Society, 13, 218-232.
59. Yang, L., et al. (2022). Wearable Renewable Energy Harvesters. Sustainable Electronics Journal, 12, 105-116.
60. Zhang, Z., et al. (2021). Photovoltaic Smart Sensors for Real-Time Monitoring. Sensors Journal, 19, 1014-1030.
61. Choi, H., et al. (2023). Enhanced Performance of Energy Harvesting Sensors. NanoEnergy Materials, 6, 234-248.
62. Zhao, M., et al. (2023). Bio-Based Materials for Energy Sensors. Energy and Environmental Science, 29, 234-248.
63. Liu, X., et al. (2023). Smart Energy Harvesting Sensors. Environmental Technology & Innovation, 10, 220-230.
64. Lee, J., et al. (2023). Advanced Solar Sensors for Energy Harvesting. Solar Energy Journal, 35, 123-136.

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Study on Ambient Air Quality Parameters of Mauganj City, (M.P) India

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ABSTRACT

The present study aims to measure the concentration of various pollutants present in the ambient air. The primary focus of the study was on the Particulate Matters (PM10 and PM2.5), although it also deals with other pollutants like SO_2 and NOx at three different sites of Mauganj city. The results revealed that the ambient air of Mauganj city is deteriorated mostly by particulate matters (PM10 and PM2.5) followed by gaseous pollutants like Sulfur dioxide (SO_2) and Nitrogen oxides (NO_x). Results of investigation indicates that concentration of PM10 is exceeding the National Ambient Air Quality Standard (NAAQS) at Commercial area whereas the concentration of SO_2, NOx is bellowing the prescribed limits. Increasing vehicular activities are more responsible for the emission of particulate matter PM10. The major causes includes inadequate improper traffic management system, road condition, absence of effective mass rapid transport system.

Keywords : Ambient air quality, Particulate Matter, SO_2, NO_x.

Introduction :

Air pollution is considered to be primarily an urban problem as the rate of industrialization and unsystematic urbanization increases day by day. It has become a major environmental problem faced by the people globally in both developing and developed countries and India is one of them. Pollutants into the air by means of various natural as well as anthropogenic means, released in the air due to various industrial as well as commercial activities and ongoing construction work along with increase in the number of vehicles. The high level of pollutants which contribute to ambient air pollution are PM10 and PM2.5 ,SO_2, NO_x, and other air pollutants affects every one of us.

Air Quality is a major concern for human health in cities where a large portion of the population lives and the pollution levels often exceed the limit values (kumar et al.,) Zheng et al,2017). Out of all pollutants PM2.5 poses a greater risk as it can penetrate deep into the lungs of human body (Xing et.al., 2016). It is observed that exposure to outdoor PM2.5 is the fifth leading risk factor world wide and the third leading risk factor in India.
Vehicular emission are one of the major sources of air pollutants and have a powerful negative effect on germination and growth of plants. These pollutants may induce plant responses leading to observable changes in their morphology plant responses may vary depending on the amount of pollutants to which they are exposed. Although this has been an intense area of research which need further studies. More plants at young stage are encouraged to be planted along roadsides as potential species since they apparently indicate the symptoms of pollutants intake in terms of stomatal index and biochemical traits to improve local air quality.

Automobiles and construction works going on in the city are the main source of pollution in urban atmosphere of Mauganj city. This deteriorated air quality lay a recognizable adverse impact on roadside plants as well as on human health of the city population. Present research work was undertaken to study the ambient air quality of Mauganj city since it is the developing city of newly founded Mauganj district.

Material and Methods

Site selection-

The present research work was undertaken in Mauganj city, which is situated on the north- eastern part of Madhya Pradesh state, central part of India. It is the fifty third district in M.P. and the fifth district in the Rewa division. It was created in 2023 by separating from Rewa district. It lies between 24.68°N and 81.88°E.

Sampling and Monitoring

On the basis of anthropogenic activities and relative traffic load, air quality monitoring has been carried out at three different sites in Mauganj city have been carried out viz. : Site-1-Residential area (Hanuman Mandir), Site-2-commercial area (Barahta mod) and Site-3- SKN P.G.College, Mauganj for six month (May 2024 to October 2024). Sampling was carried out at the three different locations using Respirable Dust Sampler (Envirotech Model APM 460 BL-411) and Gaseous pollutants Sampler (Envirotech Model APM 443) for 8 hours in a day as per the standards of Central Pollution Control Board (India). Filter papers and cyclone cup were replaced at interval of 8 hours as per CPCB norms and

conditions. PM2.5 Sampler (Envirotech Model APM 550 MMFC) for 24 hours as per the standards of Central Pollution Control Board (India). Particulate matter PM10 and PM2.5 were collected on the dust cup and glass fibre filter paper (GRA-3) respectively. Samples for determination of gaseous pollutants (SO2 and NOX) were collected by bubbling air samples in Potassium Tetra Chloromercurate and Sodium Hydroxide-Arsenite absorbing solutions filled in impingers, respectively. After sampling, the samples were analyzed for SO_2 and NO_x spectrophotometrically.

Results And Discussion :-

Ambient air quality at various stations was monitored covering a period of six months from May 2024 to October 2024 by using filter papers for RDS & PM2.5 sampler. Compared with CPCB Gazette notification National Ambient Air Quality Standards 2009. The statistical results of PM10 for different sites have been presented in table 1.The observed minimum PM10 concentration was 43.84 µg/m³ and maximum was 62.88 µg/m³at Site-1 (Residential Area). Minimum PM10 concentration was 54.91 µg/m³ and maximum 79.84 µg/m³ at Site-2 (Commercial area) and minimum concentration of PM10 was 44.95 µg/m³ & maximum concentration was 71.85 µg/m³ at Site-3 (Commercial area).Average PM10 concentration was 53.36 µg/m³, 69.54 µg/m³ and 53.27 µg/m³, site-1,Site-2 & site-3 respectively. It was noticed that average concentration of PM10 and PM2.5 are comparatively more than as compared to Site-1 & Site-3. Monthly variations are also found at all sites. During the month of October the concentration of PM10, PM2.5, SO_2 and NOx are found to be maximum because of the festival activities like Dussehra, Diwali & starting of winter season.

Table 1. Monthly average concentration of PM10 (µg/m³) at three sites of Mauganj City, Distt.Mauganj(M.P.)

Mauganj City,Distt.Mauganj(M.P.)

Month	Site-1 (Residential area)	Site-2 (Commercial area)	Site-3 (Commercial area)
May	51.90	71.85	57.93
June	56.82	68.84	54.98
July	43.84	54.91	44.95
August	49.85	65.94	48.97
September	54.89	75.88	50.86
October	62.88	79.84	61.95

Table 2. Monthly average concentration of $PM_{2.5}$ (µg/m³) at three sites of Mauganj City,Distt.Mauganj(M.P.)

Month	Site-1 (Residential area)	Site-2 (Commercial area)	Site-3 (Commercial area)
May	14.97	16.63	15.39
June	14.14	15.80	17.88
July	12.06	14.14	14.14
August	10.39	14.97	12.06
September	15.80	18.71	18.71
October	16.63	20.79	19.96

Table 3. Monthly average concentration of SO_2 (µg/m³)at three sites of Mauganj City, Distt.Mauganj(M.P.)

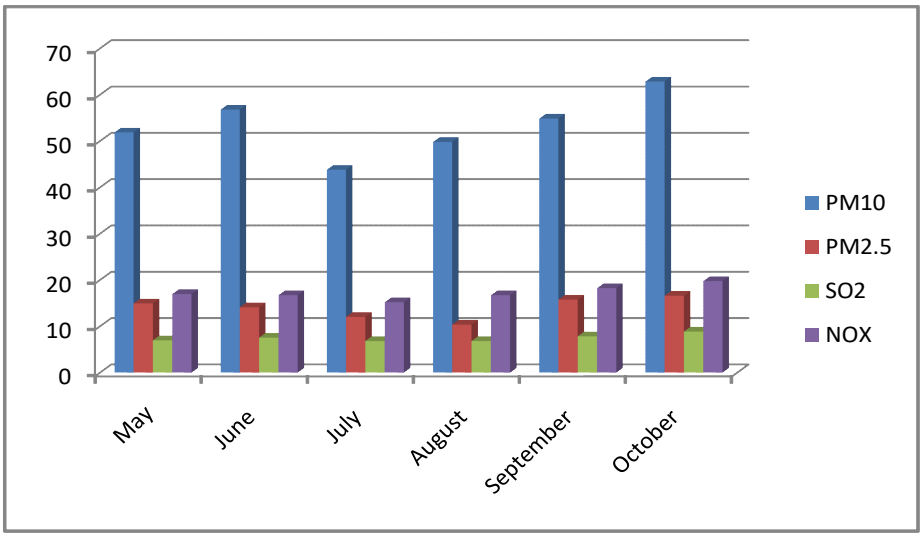
Month	Residential area	Commercial area	Commercial area
May	7	7.58	7.87
June	7.58	7.87	6.85
July	6.85	7	6.70
August	6.85	6.70	6.56
September	7.87	8.45	7.87
October	8.89	8.89	8.16

Table 4. Monthly average concentration of NOx (µg/m³) at three sites of Mauganj City, Distt.Mauganj(M.P.)

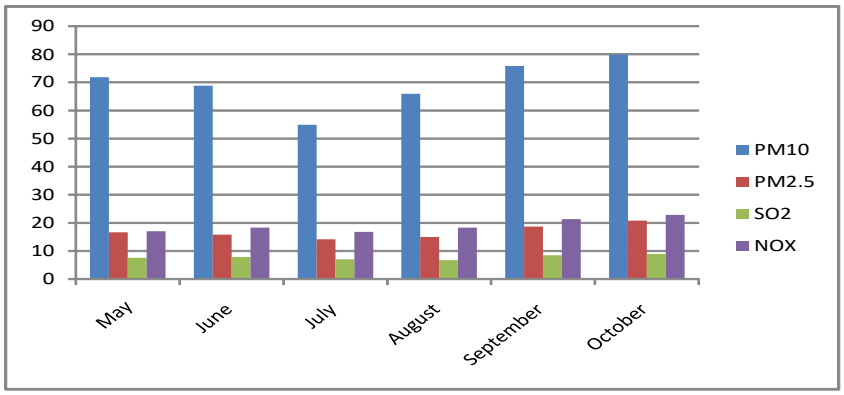
Month	**Site-1 (Residential area)**	**Site-2 (Commercial area)**	**Site-3 (Commercial area)**
May	17.01	17.01	18.29
June	16.76	18.29	17.18
July	15.24	16.76	16.76
August	16.76	18.29	15.24
September	18.29	21.34	19.56
October	19.81	22.86	21.34

Table 5. Average concentration (µg/m³)of different pollutants for six Months at three sites of Mauganj City,Distt.Mauganj(M.P.)

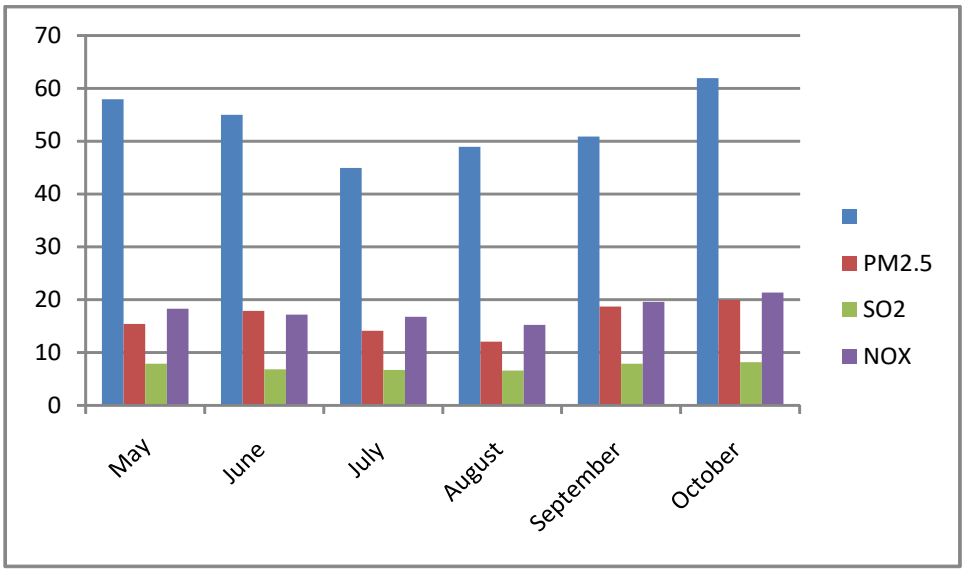
Sampling sites	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	SO_2 ($\mu g/m^3$)	NO_x ($\mu g/m^3$)
Site-1 (Residential area)	13.99	53.36	7.50	17.31
Site-2 (Commercial area)	16.84	69.54	7.74	19.09
Site-3 (Commercial area)	16.35	53.27	7.33	18.06



Monthly concentration of parameters PM_{10}, $PM_{2.5}$, SO_2,NO_X in the ambient air at Hanuman Mandir of Mauganj City



Monthly concentration of parameters PM_{10}, $PM_{2.5}$, SO_2,NO_X in the ambient air at Barahta Mod of Mauganj City



Monthly concentration of parameters PM_{10}, $PM_{2.5}$, SO_2,NO_X in the ambient air at SKN College, Mauganj

NATIONAL AMBIENT AIR QUALITY STANDARDS (2009)

Pollutants	Time Weighted Average	Concentration in AmbientAir	
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)
Sulphur Dioxide (SO_2),µg/m^3	Annual* 24 Hours**	50 80	20 80
NitrogenDioxide (NO_2), µg/m^3	Annual *24Hours**	40 80	30 80
Particulate Matter (Sizeless than 10µm) Or PM10,µg/m^3	Annual *24Hours**	60 100	60 100
Particulate Matter (Sizeless than 2.5µm) or PM2.5, µg/m^3	Annual *24Hours**	40 60	40 60

Conclusion:-

Urban air pollution are going to be day by day growing due to commercial activities, which requires immediate attention on the part of Town & County Planning. The detailed background information on urban air quality status is very much essential for local agencies to implement the air quality management programme. Mauganj city has a high potential for air pollution due to its a newly developing and highly growing city since Mauganj is going to have new administrative structure, that's why the rate of urbanization and vehicular emission increases and dust contributing a major share of the deteriorating ambient air quality in Mauganj city. The analyzed values of PM10 , PM2.5 ,SO2 and NOx at the sampling sites clearly illustrates that the ambient air quality of Mauganj city is primarily deteriorated by particulate matters (PM10 , PM2.5) followed by by gaseous pollutants (SO2 and NOX). However, this requires a systematic, cost effective and efficient air quality monitoring and modeling procedure for Mauganj city.

References

1. Agrawal, M. and Agrawal, S.B.1990. Phytomonitoring of air pollution around a thermal power plant. Atmosphere Environment 23:763-769.
2. Agrawal, M. and Singh, J. 2000. Impact of coal power plant emission on the foliar elemental concentrations in plants in a low rainfall tropical region. Environmental Monitoring and Assessment 60: 261-282.
3. Ahmad, A. and Bano, N. 2015. Ambient air quality of Firozabad city- a spatio-temporal analysis. Journal of Global Biosciencesvol. (4): pp.1488-1496.
4. Aihara, K.1996 Evaluation of air pollution using indictor plants. KankyaGijustu. 25: 674-680.
5. Banerjee, S.K. and Sett R. 2007. Fly ash: Characteristics, environmental impact and possible utilization. Pollution Managementpp :51-76.
6. Barman,S.C., Kumar,N. and Singh,R. 2010.Assesment of urban air pollution and its probable health impact. Journal of Environmental Biology 31(6):931-920.
7. Bhaskar, B.V. and Mehta V.M. 2010. Atmospheric Particulate pollutants and their relationship with Meteorology in Ahemdabad. Aerosol and Air quality Research 10: 301- 315.
8. Balashanmugam, P., Ramanathan, A. R., Nehru V. 2012. Assessment of ambient air quality in chidambaram a south Indian town. Journal of Engineering Science and Technology Vol. 7, No. 3: 292 - 302.
9. Chaurasia,S., Karwaria A. and Gupta A.D. 2013. Air pollution and Air quality Index of Kodinar Gujarat, India. International Research Journal of Environmental Sciences 2: 62-67.
10. Chaudhary, P., Singh, D., Kumar, J. and Singh, S.K. 2013. Assessment of Ambient Air Quality in Northern India using Air Quality Index Method. Bulletin of Environmental and Scientific Research 2: 12-17.
11. Charan, P.D. and Sahel, H. 2014. Study of Respirable dust in Ambient Air of Bikaner city and its Imapct on Human Health. Applied Journal of Hygiene 3: 11-14.
12. Chaurasia, S., Dwivedi, P., Singh, R. and Gupta, A.D. 2013. Ambient Air Quality Status and air quality Index of Bhopal City (Madhya Pradesh). India.International Journal of Current Science 9: 96-101.
13. Gohain ,M. and Kalita, K.,2016. Analysis of ambient air quality in guwahati city - a case study. International journal of engineering sciences & research technology 5.(3):436-443.
14. Guttikunda, S. and Jawahar, P. 2011. Urban Air Pollution Analysis in India. Urban Emissions. Info, New Delhi, India.
15. Jhamaria, C. and Jadon, S. 2016.Evaluation of Ambient Air Quality at a Sensitive Area of Jaipur. Rajasthan. International Journal of Scientific ResearchV (5):10-11
16. Joshi, S.D.1991. A few measurements on ambient air pollutants of Udaipur city. Indian Journal of Environmental Health 33: 31-39.
17. Mangalekar, S.B., Jadhav A.S. andRaut, P.D. 2014.Studies on Ambient Air Quality Status of Kolhapur City, Maharashtra, India Vol. 12, No. 3: pp. 15-22.
18. Meenakshi, P. and Saseetharan, M.K., 2004. Urban Air Pollution Forecasting with Respect to SPM using Time Series Neural Networks Modelling Approach - A Case Study in Coimbatore City, Journal of Environmental Science and Engineering 46: pp 92- 101.
19. Mohammed, U.P.,Gokularani, S., Vikram, M.,Sankar, L.,Sharpudin, J. 2014. Ambient air quality monitoring at Arcot town. International Journal of Emerging Technology and Advanced EngineeringV 3(4):329-334.
20. Nagdeve, D.A.,2004. Urban air pollution and its influence on health in India. IIPS Mumbai, ENVIS center.01:03.
21. Nair, N., Bamniya, B.R., Mahecha, G.S. and Saini, D. 2014. Analysis of Ambient Air pollution and Determination of Air Quality Status of Udaipur, Rajasthan, India. International Research Journal of Environmental Sciences 3: 5-10.
22. Nandanwar, N.P., Dixit, A.K., Dixit, K.R., Wazalwar, S.S. 2014.Comparative study of Ambient Air Quality around Chandrapur. International Journal of Scientific Engineering and Technology 3(3): 267-275
23. Nolte, C.G., Schauer,J.J., Cass, G.R. and Simoneit, G.R.,2002. Trimethylsilyl derivatives of organic compounds on source samples and in atmosphere i.e. fine particulate matter. Environmental Science and Technology 36: 4273- 4281.
24. Rai, P. and Mishra, R. 2015. Study of Seasonal concentration of SPM, RSPM, SO2 and NOX in the ambient air near J.P. cement plant, Rewa

(M.P.). International Journal of Pharmacy & Life Sciences 6(2):4251-4255.

25. Sharma,K.,Singh, R., Barman, S.C., Mishra, D., Kumar,R.,Negi, M.P.S., Mandal, S.K., Kisku, G.C., Khan, A.H.,
26. Kidwai, M.M. and Bhargava, S.K.,2006. Comparison of trace metals concentration in PM10 of different location of Lucknow city. Bulletin of Environmental Contamination and Toxicology 77: 419-426.
27. Sharma, S .K. and Sharma, K., 2016. Ambient Air Quality Status of Jaipur City, Rajasthan, India. International Research Journal of Environment Sciences Vol. 5(1): 43- 48.
28. Shrivastava, R. K.; Saxena, N. and Gautam, G., 2013. Air pollution due to road transportation in India: a review on assessment and reduction strategies. Journal of Environmental Research and Development Vol. 8:69-77.
29. Shukla V., Dala P. and Chaudhry D. 2010. Impact of Vehicular Exhaust on ambient air quality of Rohtak city, India. Journal of Environmental Biology 31: 929-932.
30. Song, J., Guang,W., Li, L. and Xiang, R.,2016. Assessment of Air Quality Status in Wuhan, China. Atmosphere7:56.
31. Street, R.A.; Duckham, S.C. and Hewitt, C.N. 1996. Laboratory and field studies of biogenic volatile organic compound emission from Sitka spruce (PiceasitchensisBong.) in the United Kingdom. Journal of Geophysics Research Atmospheres 101: 22799- 22806.
32. Tsang H., Kwok R., and Miguel, A.H. 2008. Pedestrian Exposure to Ultrafine Particles in Hong Kong under Heavy Traffic Conditions. Aerosol Air Quality Research 8: pp 19- 27.
33. Watkins, LH. 1991. Air Pollution from road vehicles, Transport and Road Research Laboratory, London, UK.
34. Yadav, S.K., Kumar, V. and Singh, M.M. 2012. Assessment of Ambient Air Quality Status in Urban Residential areas of Jhansi city and Rural Residential areas of adjoining villages of Jhansi city. International Journal of Advances in Engineering and Technology 3:280-285.

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Assessment of Toxicity Due to Herbal Drugs: A Review

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Abstract

Herbal medicines have been utilized for centuries across various cultures for their therapeutic properties. Despite their perceived safety, numerous reports indicate potential toxicity, which can compromise patient health. This paper reviews the mechanisms of toxicity, types of toxic reactions, regulatory frameworks, and methodologies for toxicity assessment of herbal drugs. Emphasis is placed on hepatotoxicity, nephrotoxicity, and neurotoxicity, along with analytical and preclinical techniques for evaluating herbal safety. Herbal drugs, also known as phytomedicines, are widely used for their perceived natural benefits. However, "natural" does not always equate to "safe." Like synthetic drugs, herbal medicines can also cause toxicity, either due to their intrinsic properties or through contamination, adulteration, or improper use. Assessing the toxicity of herbal drugs is essential to ensure their safe use and to prevent adverse health outcomes.

Keywords: herbal, medicines, misconceptions, adulteration, metabolites.

1. Introduction

The global use of herbal medicines has seen resurgence due to their accessibility and perceived safety. According to the World Health Organization (WHO), approximately 80% of the world's population uses herbal remedies as part of their primary healthcare. However, misconceptions regarding their safety have led to increased incidences of adverse effects, highlighting the importance of toxicity assessment. Even though herbal medicine products are usually perceived as low risk, their potential health risks should be carefully assessed. Several factors can cause the toxicity of herbal medicine products: plant components or metabolites with a toxic potential, adulteration, environmental pollutants (heavy metals, pesticides), or contamination of microorganisms. Their correct evaluation is essential for the patient's safety. The toxicity assessment of herbal medicine combines in vitro and in vivo methods, but in the past decades, several new techniques emerged besides conventional methods. The use of omics has become a valuable research tool for prediction and toxicity evaluation, (1) while DNA sequencing can be used successfully to detect contaminants and adulteration. The use of invertebrate models became popular due to the ethical issues associated with vertebrate models. The aim of the present article is to provide an overview of the current trends and methods used to investigate the toxic potential of herbal medicinal products and the challenges in this research field.

1.1 Importance of Toxicity Assessment

The toxicological profile of herbal drugs is often underexplored due to limited clinical data, inconsistent quality control, and the presence of bioactive compounds with unknown pharmacokinetics and pharmacodynamics. The toxicity assessment portion is where toxicologic pathologist is most directly involved. This stage of risk assessment involves identifying potential hazards and developing dose-response information for effects of interest. In general, the most sensitive adverse effect, i.e., that adverse effect which is likely to occur at the lowest dose under the expected conditions of exposure, is identified as the "critical" effect. In environmental assessments, the critical effect is used to develop reference values that represent doses below which significant adverse effects are not expected under the anticipated exposure conditions (2). The logic used here is that if exposures are such that the critical effects cannot occur, other adverse effects that occur only following more intense, prolonged, or frequent exposures will not occur. In pharmaceutical safety assessment, the basic principle is the same. Dose levels, which are devoid of adverse effects, are established and referred to as No Observed Adverse Effect Levels (NOAELs), and these values are used to define margins of safety. A common dilemma for all toxicologists and pathologists is the subjectivity of determining if an effect observed in an animal study is "adverse." Despite a longstanding debate, there is not a universally accepted definition of "adverse." Certain findings, such as mortality or hepatic necrosis, are clearly adverse; however, many of the effects, such as a minor shift in the incidence of a background lesion, are much more difficult to interpret. This type of uncertainty and subjectivity can readily lead to distrust by other scientists or the lay public, and result an erroneous perception of risk.

2. Mechanisms of Herbal Drug Toxicity (3)

Herbal drug toxicity can arise from various mechanisms:

* Direct Toxicity: Due to inherent toxic constituents.
* Bioactivation: Metabolic conversion of herbal constituents into reactive metabolites.
* Idiosyncratic Reactions: Unpredictable adverse effects that occur in a small subset of individuals.
* Contamination: Presence of heavy metals, pesticides, or microbial contamination.
* Adulteration: Addition of synthetic drugs or other herbs to enhance efficacy.

3. Common Types of Herbal Drug Toxicity

3.1 Hepatotoxicity

The liver is a primary site of herbal drug metabolism and a common target of toxicity. Drug metabolic pathways of liver and hepatotoxicity. The liver is the most prominent digestive gland that metabolizes drugs via oxidation, reduction, hydration, hydrolysis, condensation, conjugation, or isomerization (4). Two stages of hepatic drug metabolism convert pharmaceuticals into conjugated water-soluble substances via P450 enzymes, which are excreted via urine or bile. Although the liver metabolizes drugs, disruption of these processes can lead to hepatotoxicity. Hepatotoxicity occurs through numerous mechanisms: disassembly of hepatocytes, apoptosis of hepatocytes, injury to bile duct, inhibition of mitochondria, and cytolytic T-cell activation. Data regarding herbal hepatotoxicity can be found in case series and case reports. The expression of hepatotoxicity originates with weight loss, malaise, jaundice, dyspepsia, blood coagulation, oedema, and pruritus. Hepatic symptoms scope from clinically asymptomatic to chronic symptoms. Mechanisms and treatments for hepatoprotection and hepatotoxicity. Once hepatotoxicity is initiated, patients express the following symptoms: hepatic necrosis, fibrosis, vomiting, bleeding, swelling of the legs and feet, elevated serum transaminases, bilirubin, or cholestasis, liver cirrhosis, liver failure, and hepatic veno-occlusive disease (5). Cirrhosis is marked by the degeneration of nodules enclosed by the fibrous glands of the liver, causing high portal blood pressure, and ultimately liver disease, due to deformity of hepatic vasculature. There are two forms of hepatotoxin-induced liver injury:Idiosyncratic injuries result from the formation of reactive metabolites and activation of the immune system. It is doseindependent and predictable. Intrinsic liver injuries are dosedependent and reproducible. Numerous factors make determination of herbal hepatotoxicity difficult and include: production and storage processes, contamination, pharmacodynamics properties, and pharmacokinetic properties (6). Drug-induced liver injury occurs in many patients with acute liver injury, and without obvious etiology. Known information regarding the hepatotoxicity of the causative agent is helpful in diagnosis. However, documentation of hepatotoxicity in the medical literature is variable. Researchers need accurate information on the diagnosis, frequency, causes, and patterns of liver injury attributable to herbal medicines.

3.2 Nephrotoxicity

Ayurveda:

A traditional system of medicine originating in India Ayurveda, Science of Life, is a traditional system of medicine from around 1500 B.C. with distinct concepts of integrated medicine, derived from the Indian philosophies Samkhya and Nyaya vaisheshika. Ayurveda considers the physical, psychological, philosophical, ethical, and spiritual well-being of the individual (6). Five basic elements exist to maintain equilibrium, Prithvi, Jala, Teja, Vayu, and Akash. When equilibrium is disturbed, disease results. Based upon one?s psychosomatic constitution, there are specific daily, Dinacharya, and seasonal, Ritucharya, routine to maintain optimal human health. Of the several medicinal plants used in Ayurveda, some well-studied plants related to hepatotoxicity are discussed below. Turmeric, Curcumin longa, is of the Zingiberaceae family and curcuma genus. Humans consume the root, a rhizome, most commonly consumed as a powder. In Sanskrit, turmeric, sarvoshadhi, means "medicine for all diseases." The principle constituent Curcumin gives turmeric its yellow appearance. Ayurvedic medicine utilizes turmeric for its antibacterial, antiseptic, and anti-inflammatory properties, (7) as well as a pain-killer, weight-reducer, cosmetic cream, and hepatoprotector. Researchers demonstrated that curcumin protects the liver against carbon tetrachloride-induced liver injury in rats. Research scientists induced hepatic stress via an intraperitoneal injection of CCl4 (0.1 ml/hg bw). Also administered were turmeric and curcumin extracts once per day for four weeks at 100, 200, and 300 mg/kg/d. The extracts provided protection against hepatic damage by suppressing oxidative stress and lowering levels of serum aspartate aminotransferase and alanine aminotransferase. This yields higher levels of hepatic glutathione, reducing lipid peroxidases (8). Garlic, Allium sativum, is of the Liliales family and Allium L. genus. Humans consume all parts of the plant, except the rhizome, wrappers of the garlic bulb, and the root cluster. The cloves are most commonly consumed either raw or cooked. Ayurvedic medicine uses garlic as

an antibiotic to lower diuretic, expectorant, antitussive, lipid, and blood pressure levels. Garlic lowers systolic blood pressure, and thus treats hypertension.

Furthermore, garlic strengthens the immune system by fighting diseases such as cancer, particularly stomach, colon, prostate, and breast cancer. Aged garlic extract demonstrates the delay of ischaemia-induced neuronal injury. It has low toxicity, although the following adverse reactions have been reported: upset stomach and skin rashes. Most notably, garlic provides hepatoprotection against gentamycin-induced hepatotoxicity in rats. Adult male rats were fed 2% and 4% garlic for 27 days pregentamycin administration. Rats adhering to a garlic diet demonstrated a restoration of antioxidants due to the presence of sulpur-containing compounds and flavonoids [19]. Amla, Emblica The Journal of Phytopharmacology 189 officinalis, is of the Phyllanthaceae family and Phyllanthus genus. Human consume the dry powder of the fruit, and as a topical cream. In Ayurvedic medicine, Amla is believed to maintain the balance between all three doshas. Amla has great amounts of vitamin C. One hundred grams of amla presents 700 mg of vitamin C, thirty times that of an orange (9). Amla alleviates the adverse effects of hyperacidity and ulcers, as well as strengthens immunity, improves vision, scavenges free-radicals, and reduces cholesterol. Amla fruit extracts provided hepatoprotection against alcohol-induced hepatic injury in rats as demonstrated by in-vivo administration of 5 g/kg bw for 60 days into two-month old male albino Wistar rats, (120-140 g) and resulted in an increase in liver lipid peroxidation, nitrite plus nitrate levels, and protein carbonyls. The administration of alcohol at 250 mg/kg bw was found to lower superoxide dismutase, glutathione peroxidase, catalase, glutathione, and glutathione S-transferase . Tulsi, Ocimum sanctum Linn, is of the family Labiate and genus Ocimum. Humans consume the raw or prepared leaves as a tea or powder. In Ayurvedic medicine, tulsi is used to lessen the effects of respiratory diseases like bronchitis and bronchial asthma, malaria, diarrhea, arthritis, heart disease, insect bites, and chronic fever. The active component in tulsi is eugenol, and gives it its therapeutic properties (10). Lahonet al. proved the hepatoprotective effects of tulsi against paracetamol-induced liver damage in albino rats (150-200 g) when combined with silymarin. Three rat groups were given the following preparations: alcoholic extract of Ocimum sanctum leaves at 200 mg/kg/bw/d, silymarin at 100 mg/kg/bw/d and OSE 100 mg/kg/bw/d and silymarin 50 mg/kg/bw/d p.o. for ten days. On day eight, 2g/kg/bw/d of paracetamol was administered to induce hepatotoxicity. Results demonstrated that Ocimum sanctum alcoholic leaf extract provided hepatoprotection, as demonstrated by normal levels and maintained normal levels of liver enzymes and albumin globulin . Ginger, Zingiber officinale, is of the Zingiberaceae family and Zingiber officinale Roscoe species. The rhizome, or underground stem, is consumed in the form of powder, teas, oils, and extracts.

The active ingredients, the gingerols in particular 6-gingerol, alleviate the following symptoms: motion sickness, nausea, vomiting, vertigo, respiratory congestion, and hypoglycemia (11). Researchers have studied the effects of the hydroalcoholic extract of ginger on the liver of epileptic female rats that have been treated with lamotrigine. Lamotrigine is an anti-epileptic drug. Prolonged use contributes to hepatotoxicity. To investigate, forty-eight female Wistar rats were given 10 mg/kg/d of lamotrigine via gavages for four weeks. Researchers induced epilepsy via injections of pentylenetetrazol at 40 mg/kg. This demonstrates that the hydroalcoholic extract of ginger advances liver function in lamotrigine-induced hepatotoxicity. Plants that cause hepatotoxicity There are three types of hepatotoxicity: cholestatic,hepatocellular, andmixed. Cholestasis occurs when substances expelled via bile are disrupted due to impaired excretion of hepatocytes. Hepatocellular damage occurs when infection or cancer affects liver cells. Substances that result in hepatotoxicity include pharmaceuticals drugs and medicinal plants. As an example, overdose on acetaminophen is a common cause of drug-induced hepatotoxicity caused due to its metabolite diminishes glutathione, leading to apoptosis of hepatocytes and hepatocellular necrosis.

Anticoagulants, such as ximelagatran, acenocoumarin, heparin, and warfarin, are used to prevent venous thromboembolism. Patients begin with elevated serum transaminases, and subsequently develop hepatitis, and liver failure (12). Antimalarial pharmaceuticals such as amodiaquine, contributes to hepatotoxicity due to oxidation of a reactive metabolite, named iminoquinone. This metabolite binds irreversibly to proteins, disturbing cellular functions (13). In addition to pharmaceutical drugs, research scientists have discovered medicinal plants that contribute to hepatotoxicity. Links between hepatic damage and herbal medicines are concerning to research scientists. Liver damage includes the following disorders: elevated liver enzymes, acute or chronic hepatitis, cholestasis, hepatic necrosis or fibrosis, cirrhosis, liver failure, and hepatic veno-occlusive disease. Actearacemosa is a perennial woodland herb native to North America. The active constituents include

terpene glycosides like actein, cimicifugoside, and 27-deoxyactein, alkaloids, flavonoids, and tannins. This plant is associated with acute hepatitis and liver failure . Symphytum officinale L. is a common garden plant belonging to the Boraginacaea family.

Pyrrolizidine alkaloids are a major content of this plant and the main hepatotoxic effect is hepatic veno-occlusive disease. Germander contains diterpenoids, which cause hepatocyte apoptosis. Green tea is extracted from Camellia sinensis leaves and is safe in average amounts, however excessive catechins causes hepatocellular injury. Extracts from symphytum causes venoocclusive disease as it contains pyrrolizidine alkaloids. Moreover, piper methysticumis used for anxiety and sleep disorders and leads to hepatotoxicity. Cimicifugaracemosa is used for menopause and dysmenorrhea, and contains glucosamine supplements and causes severe hepatotoxicity. Chelidonium majus is used for dyspeptic symptoms, and cascara sagrada, a herbal laxative containing anthracene glycoside. The liver is the main organ of drug metabolism, so it is the target organ of drug-induced injuries. In the liver, foreign chemicals are transformed by the metabolizing enzymes; microsomal cytochrome P450, mixed-function monooxygenases, UDPglucuronosyltrans-ferases, sulfotransferases, and glutathione-Stransferases. Medicinal plants are self-prescribed and widely available so they are difficult to control (14) . Establishing a causal relationship between pharmaceutical drugs, medicinal plants, and liver injury is challenging due to the variable composition of the plants, and their respective ingredients. To assess the causal relationship, other causes of liver injury must be excluded, such as hepatitis, autoimmune diseases, metabolic, and genetic diseases. Two methods are used to assess liver injury: expert opinions, and the RousselUclafassessment method. This method calculates a score based on clinical, and biochemical parameters. High scores indicate increased chance of hepatic injury.

Mortality and morbidity statistics Hepatitis C is marked by inflammation of the liver due to a virus in the blood, usually from the use of blood-to-blood contact, shared needles, or mother-to-offspring transmittal. Left untreated, Hepatitis C causes liver cancer, liver disease, and cirrhosis. The Centers for Disease Control?s study of Hepatitis C demonstrated that the mortality rate of Hepatitis C in 2013 exceeded the total collective deaths from sixty infectious diseases, including tuberculosis and HIV.(15) In 2014, the CDC reported 19,659 total deaths. An estimated three and a half million Americans have the disease, with those born between 1945- 1965 showing the highest risk due to medical procedures involving needles and blood transfusions. Approximately 175 million worldwide test positive for Hepatitis C and 350,000 die per year. Three to four million people are diagnosed each year. Chronic hepatitis C is the eminent cause of cirrhosis at 27% and hepatocellular carcinoma at 25%. Chronic Hepatitis C kills 2.4 million worldwide The Journal of Phytopharmacology 190 per year. Patients with alcoholic cirrhosis comprise 30-50% for liver transplants (16). The incidence of cirrhosis worldwide is unclear. However, in the United States of America, is accounts for 0.15%, or 400,000 cases, as well as more than 25,000 deaths and 373,000 hospital visits in 1998. The European nation reflect similar values, while Asian and African countries demonstrate higher values due to the prevalence of Hepatitis B and C.

4. Regulatory Frameworks for Herbal Drug Safety

The first international recognition of the role of traditional medicine and use in primary health care was in The Declaration of Alma-Ata. It states, inter alia, that ".Primary health care relies, at local and referral levels, on health workers, including physicians, nurses, midwives, auxiliaries and community workers as applicable, as well as traditionalpractitioners as needed." (17). The safety problems emerging with herbal medicinal products are due to a largely unregulated growing market where there is a lack of effective quality control. Lack of strict guidelines on the assessment of safety and efficacy, quality control, safety monitoring and knowledge on traditional medicine/complementary and alternative medicine (TM/CAM) are the main aspects which are found indifferent regulatory systems. Under some regulatory systems plant may be defined as a food, a functional food, a dietary supplement or a herbal medicine.

Table 1; Permissible limit for some heavy metal in herbal drugs.

Test for heavy /toxic metals	WHO	US Food and Drug Administration (FDA)	Department of Homoeopathy	Ayurveda, Unani, Sidhha (AYUSH) India
Lead	10.0 ppm	10.0 ppm	10.0 ppm	20 ppm
Mercury	1.00 ppm	1.00 ppm	1.00 ppm	0.5 ppm
Arsenic	10.0 ppm	10.0 ppm	10.0 ppm	5 ppm

As per WHO, herbal medicines include herbs, herbal materials, herbal preparations and finished herbal products that contain as active ingredients parts of plants, or other plant materials, or combinations. Similarly in the EU, the EMEA defines herbaldrugs as the whole, fragmented or cut, plants, parts of plants, algae, fungi, lichen in an unprocessed state usually in dried form or afresh. Unprocessed exudates are also considered as herbal drugs. When herbal drugs are subjected to treatments such as extraction, distillation, expression, fractionation, purification, concentration or fermentation, they are known as herbal drug preparations. This includes powdered herbal drugs, tinctures, extracts, essential oils, expressed juice orprocess exudates. Virtually all herbal products sold in the US are treated as dietary supplements and therefore as foods.

A botanical product which is derived from one or more plants, algae, or macroscopic fungi and prepared from botanical raw materials by one or more of the processes such as pulveri-zation, decoction, expression, aqueous extraction, ethanolic extraction, or other similar process, intended for use as a drugis known as Botanical Drug Product (Section 201(g)(1)(B),Federal Food, Drug, and Cosmetic Act).The safety of herbal medicines is a global concern and national health authorities have developed mandates to ensure the safe use of herbal medicines. In 2001, WHO initiated a global survey in 191 member states on national policies on TM/CAM and regulation of herbal medicines. Research data, appropriate control mechanisms, education of providers and expertise are identified to be most important for the field of regulation of herbal medicine (18). The survey revealed that till 2003, 37% of member states had laws andregulations for herbal medicine, out of this 42% member states had separate laws and regulation. Further it was found that nearly 68% of member countries sell herbal medicines as Over the Counter (OTC) drugs and about 35% of member states treat herbal medicines as prescription medicines.

Medical claims, health claims and nutrients content claims are the most common types of claims with which herbal medicine may legally be sold. Only 24% of responding countries indicated that national pharmacopoeia for herbal drug existed and in use and 18% countries indicated that sucha document was in preparation. Fifty one percent countries indicated that the same GMP rules as for conventional pharmaceuticals are also applicable to manufacturing of herbal drugs. Out of the total 142 responded member states only 15% members have herbal medicines included in their essential medicine list. China reported highest 1242 herbal medicines in the essential medicine list (19). Some of the parameters that help in understanding the development of herbal drug regulation in a given nation are general policy structure, drug registration system, development of pharmacopoeia, national monographs, inclusion inessential medicine list and drug type (OTC or prescription).Using these parameters we have compared the herbal drug regulation in South East Asian and some Western Pacific countries. Of the eighteen countries studied, except Bhutan, Sri Lanka and Maldives, all countries have herbal drug regulation and registration system.

Nine countries (Korea, Indonesia, India, Myanmar, Sri Lanka, Thailand, China, Malaysia, and Vietnam) have their National Monographs for herbal drugs. In Bhutan, Nepal and Philippines the development of monographs are in progress. Pharmacopoeias for the herbal medicines are developed in fifteen countries (except for Maldives, Malaysia and Singapore). In seven countries, Bhutan, India, Thailand, China, Philippines, Republic of Korea and Vietnam, the essential medicine list includes herbal drugs. Philippines has the highest number included in the list with 2000 herbal drugs followed by China with 1242 herbal drugs. India has separate essential medicine lists for the traditional herbal drugs such as Ayurveda and Unani. Except Bhutan in all other countries, the herbal drugs are available as OTC drugs. In Bhutan, where no separate regulation for herbal drugs is available, (20) these are sold as prescription medicines only.

5. Conclusion

While herbal medicines offer significant therapeutic potential, their safety profile must not be overlooked. Comprehensive toxicity assessment using in vitro, in vivo, and clinical methods, along with stringent regulatory oversight, is essential to ensure the safe use of herbal products. Public awareness and pharmacovigilance programs can further minimize the risk of herbal drug toxicity.

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References

1. Debelle, F. D., Vanherweghem, J. L., & Nortier, J. L. (2008). Aristolochic acid nephropathy: A worldwide problem. Kidney International, 74(2), 158-169.
2. Haller, C. A., & Benowitz, N. L. (2000). Adverse cardiovascular and central nervous system events associated with dietary supplements containing Ephedra alkaloids. New England Journal of Medicine, 343(25), 1833-1838.

3. Navarro, V. J., Khan, I., Björnsson, E., Seeff, L. B., Serrano, J., & Hoofnagle, J. H. (2017). Liver injury from herbal and dietary supplements. Hepatology, 65(1), 363-373.
4. Spinella, M. (2001). The Psychopharmacology of Herbal Medications: Plant Drugs That Alter Mind, Brain, and Behavior. MIT Press.
5. Teschke, R., et al. (2012). Hepatotoxicity of kava: A critical review. Journal of Clinical and Experimental Hepatology, 2(1), 22-37.
6. Mainardi T, Kapoor S, Bielory L. J Allergy Clin Immunol 2009;123(2):283.[14] Zou L, Harkey MR, Henderson GL. Life Sci 2002;71:1579.
7. Lam Y, Poon W, Lai C, Chan AY, Mak TW. J Pharm Biomed Anal 2008;46:804.[16] Yee S, Chu S, Xu Y, Choo P. Health Policy 2005;71:133.
8. Chan K. Chemosphere 2003;52:1361.
9. Mitra SK, Kannan R. Ethnobot Leafl 2007;11:11.
10. Yap KY, Chan SY, Lim CS. Food Chem 2008;107:570.
11. Ramawat K.G., S. Goyal. The Indian herbal drugs scenario in global perspectives. In: New York: Springer Berlin Heidelberg; 2008.p.325.
12. Mazzanti G, Battinelli L, Daniele C, Costantini S, Ciaralli L, Evandri MG.Food Chem Toxicol 2008;46:3043.
13. Dargan PI, Gawarammana IB, Archer JRH, House IM, Shaw D, Wood DM.Int J Environ Health 2008;2(3/4):463.
14. Ernst E. Trends Pharmacol Sci 2002;23(3):136.
15. Rai V, Kakkar P, Khatoon S, Rawat AKS, Mehrotra S. Pharm Biol 2001;39(5):384.
16. Saper RB, Kales SN, Paquin J, Burns MJ, Eisenberg DM, Davis RB, et al. JAMA 2004;292(23):2867.
17. Saper RB, Phillips RS, Sehgal A, Khouri N, Davis RB, Paquin J, et al. JAMA2008;300(8):915.
18. Xue J, Hao L, Peng F. Chemosphere 2008;71:1051.
19. Jian X, Dongjing L, Shilin C, Yonghong L, Zhongmei Z. Mode Tradit ChinMed Mater Med 2008;10(1):91.
20. Rai V, Kakkar P, Singh J, Misra C, Kumar S, Mehrotra S. Environ MonitAssess 2008;143:273.
21. World Health Organization. WHO guidelines for assessing quality ofherbal medicines with reference to contaminants and residues; 2007
22. Bugno A, Almodovar AAB, Pereira TC, Pinto TJA, Sabino M. Braz J Microbiol 2006; 37:47.[33] Stewart KM. Ethnopharmacology 2003;89:3.
23. Warburton CL, James EA, Fripp YJ, Trueman SJ, Wallace HM, et al. Biol Conserv 2000;96:45.

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The Role of Gut Microbiota in Insect Adaptation to Extreme Environments

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Abstract

The article "The Role of Gut Microbiota in Insect Adaptation to Extreme Environments" examines the important part of gut microbiota in the ability of insects to withstand extreme eco-physiological conditions that is presence of high altitudes, extreme temperatures, and varied diets. This work uses 16S rRNA gene sequencing, metabolic profiling and controlled environmental conditions to determine the structural and functional modulation of the gut bacterial communities and the relationship of changes with the insects' physiology and behavior. It has been demonstrated that such gut bacteria as *Bacteroides*, *Ruminococcus*, *Turicibacter*, and some others, increase the capabilities of insects to survive periods of low food availability and extreme environmental conditions. For example, in the case of ladybird beetle *Micraspis discolor* the facilitative gut bacterium *Serratia marcescens* (SmMd) is involved in pollen digestion within the organism. This new understanding emphasizes the importance of studying the roles of insect gut microbiota from a symbiotic perspective. The relevance of these findings is meaningful to host microbiota association studies with special emphasis on host environmental adaptation.

This study expands on the global context of microbiology and ecology by explaining how the gut's microbiota promotes insect survival and their ability to adjust to adverse habitat conditions. There are broader implications of this study since they provide possibilities for enhancing biological control techniques as well as the persistence of the beneficial insects in different environments. Moreover, such knowledge can assist the development of approaches aimed at regulating and conserving insect populations in the presence of climate change and other environmental challenges.

Introduction

Extensive and innovative studies conducted by ecologists and microbiologists have emphasized the connections between the hosts and their associated microbiota as crucial for resilience mechanisms at the environmental level. Genetic, physiological, and microbial influences are thought to work together to enhance organism survival in harsh environments. For instance, insects, among the most diverse and hardy groups of organisms, are increasingly found to rely on gut symbionts in order to adapt to extremes such as high elevation, temperature, and dietary diversity. The purpose of this dissertation is to examine the research question of how gut symbionts allow insects to tolerate these extreme conditions. More specifically, it sets out to explore the structure and functional dynamics of gut-associated bacterial communities and the corresponding physiological and behavioral changes in the insects. This entails a combination of 16S rRNA gene sequencing, metabolic profiling and manipulations of environmental parameters in order to understand these adaptations.

The main objectives of this research are to identify specific gut bacteria that enhance insect adaptation, to determine the functional roles of these bacteria, and to explore how these microbial communities interact with the host's physiology and behavior. By achieving these objectives, this study aims to contribute to the broader understanding of host-microbiota interactions and their significance in environmental resilience.The significance of this research lies in its potential to inform strategies for optimizing biological control methods and improving the resilience of beneficial insect species in various ecological settings. Given the increasing impact of climate change and other environmental stresses on insect populations, understanding the role of gut microbiota in adaptation is crucial for developing effective conservation and management strategies. This knowledge can also have practical applications in agriculture, forestry, and other fields where insect populations play vital roles.

Literature Review

The intricate relationship between gut microbiota and host physiology has become animportant area of research in ecological and evolutionary biology, particularly in understanding how various organisms adapt to extreme environments. Insects, which display remarkable diversity and adaptability, serve as an essential focus for investigating these interactions, especially given their prevalence in harsh ecosystems ranging from arid deserts to polar ice caps. The gut microbiome-the collection of microorganisms residing in the gastrointestinal tract-has been demonstrated to play a crucial role in nutrient metabolism, immune system modulation, and stress response in various insect species.

This literature review aims to synthesise existing research on the role of gut microbiota in facilitating insect adaptation to extreme environments, thereby illuminating both the potential and limitations of these microbial communities in enhancing the resilience of their hosts.The significance of this research extends beyond questions of basic biology; understanding the mechanisms by which gut microbiota influence insect adaptability has profound implications for biodiversity conservation, agricultural productivity, and ecosystem functioning. Studies have shown that gut microbiota can confer advantages such as improved digestion of recalcitrant plant materials, resilience against environmental stressors, and increased capacity for detoxifying harmful substances-attributes that are crucial for survival in extreme habitats. Recent findings indicate that certain microbial consortia are particularly effective in enabling insects to exploit new resources or withstand conditions that would otherwise be lethal. Key themes emerging from the literature include the symbiotic relationships between insects and their gut microbes, the mechanisms underlying these interactions, and the evolutionary implications of such adaptations. Research has highlighted how insect lineages have evolved unique microbiota adapted to their specific ecological niches, with notable examples such as leafcutter ants and termites, which rely heavily on microbial assistance for digestion and nutrient absorption. Furthermore, studies have increasingly focused on the role of horizontal gene transfer and metabolic pathways that facilitate mutualistic relationships, illustrating that the adaptations conferred by gut microbiota are not solely dependent on genetic inheritance but also on microbial community dynamics. 0Despite these advances, significant gaps remain in our understanding of the role of gut microbiota in insect adaptation to extreme environments. Much of the existing research has concentrated on a select few model organisms, leaving a vast array of insect species-including those in underexplored ecosystems-largely undocumented. Moreover, there is a pressing need for a more nuanced exploration of the environmental factors that drive the composition and diversity of gut microbiota in different insect taxa. The mechanisms by which these microbial communities evolve in response to environmental pressures and their subsequent impact on host phenotype and fitness also warrant further investigation. In summary, this literature review will systematically evaluate current findings on the role of gut microbiota in insect adaptability, highlighting the interplay between host and microbes across various ecological settings. By addressing the identified gaps and proposing avenues for future research, this review seeks to contribute to a more comprehensive understanding of gut microbiota as a critical player in the adaptation of insects to extreme environments, ultimately enhancing our knowledge of ecological resilience and the evolutionary forces shaping biodiversity. The role of gut microbiota in insect adaptation to extreme environments has gained considerable attention over the past few decades, evolving through various research milestones. Early explorations into insect microbiota primarily characterised resident microbial communities, revealing their ubiquitous presence across diverse insect taxa (Charles J. Mason et al., 2023). Pioneering studies in the late 20th century demonstrated that these microbial inhabitants significantly influence the host's physiological processes, including digestion and immune responses, which are crucial in extreme environments (Ambra Masuzzo et al., 2020) (Ayushi Gupta et al., 2020). Recent investigations have focused on how gut microbiota can mediate insect responses to multifaceted stressors, including temperature fluctuations and resource scarcity, by modulating gene expression related to stress tolerance (Denis Faure et al., 2018) (J. Köhl et al., 2019). Moreover, contemporary research underscores the capacity of gut microbes to alter nutritional pathways and contribute to immune system modulation, providing insects with advantageous traits for survival in extreme habitats (Hongwei Liu et al., 2017) (Samiran Banerjee et al., 2022). Thus, the journey of understanding gut microbiota's role in insect adaptability has transitioned from mere identification to a sophisticated comprehension of its ecological and evolutionary implications (Tobin J. Hammer et al., 2021) (Samuel Latour et al., 2021). This growing body of literature signifies the importance of gut microbiota as a key factor in the evolutionary success of insects faced with increasingly challenging environments (Heribert Hirt, 2020) (Alma et al., 2012) (del Castillo et al., 2015) (Bezemer et al., 2023).

This suggests a direct link between microbial diversity and the ability to cope with changing environments. Another critical aspect pertains to the role of gut microbiota in nutrient acquisition and digestion, particularly when insects encounter limited food resources. Research indicates that specific bacterial symbionts within the gut can aid in the breakdown of complex polysaccharides, allowing insects to exploit otherwise inaccessible food sources, which is especially crucial in nutrient-poor habitats (Ambra Masuzzo et al., 2020) (Ayushi Gupta et al., 2020). Furthermore, these symbionts can enhance the insect's ability to detoxify harmful compounds present in their diet, thus promoting

survival under extreme stress conditions (Ricardo Cavicchioli et al., 2019) (Nina Montoya-Ciriaco et al., 2020). Moreover, microbial interactions can also modulate behavior, impacting foraging strategies and habitat selection, thereby influencing ecological niches occupied by insects (Claudio Franceschi et al., 2018) (Denis Faure et al., 2018). Overall, understanding the intricate relationships between gut microbiota and insect adaptation to extreme environments unveils significant implications for evolutionary biology and ecological conservation, highlighting the essential collaboration between host organisms and their microbial counterparts in facing environmental challenges (J. Köhl et al., 2019) (Hongwei Liu et al., 2017).Research on the role of gut microbiota in insect adaptation to extreme environments has employed various methodological approaches, each yielding valuable insights into this complex relationship. Some studies have relied on comparative genomics and metagenomics to determine how microbial communities associated with insects differ in extreme conditions. For instance, analyses focusing on the gut microbiota of extremophilic insects reveal that specific bacterial taxa associated with thermal resistance are more abundant in insects from high-temperature environments, suggesting a possible adaptive role of these microbes (Charles J. Mason et al., 2023) (Ambra Masuzzo et al., 2020). Such genomic investigations allow researchers to link specific genes associated with stress responses to the microbial profiles present in the gut.Other methodologies include experimental manipulation of gut microbiota through antibiotic treatments or germ-free insect models. For example, when gut microbiota are disrupted in model insects like Drosophila melanogaster, significant alterations in metabolic pathways occur, indicating how essential these microbes are for adapting to fluctuating environmental factors (Ayushi Gupta et al., 2020). Additionally, culturomics has provided a complementary perspective, revealing previously uncultured gut microbes that play crucial roles in nutrient metabolism and environmental resilience (Ricardo Cavicchioli et al., 2019) (Nina Montoya?Ciriaco et al., 2020). Field-based studies investigating host-microbe interactions in natural settings have also gained traction. Such research has shown that environmental stresses elicit changes in both insect physiology and gut microbial composition, highlighting dynamic microbiota roles in adaptation to harsh habitats (Claudio Franceschi et al., 2018) (Denis Faure et al., 2018). By integrating genomic, experimental, and ecological methodologies, researchers are beginning to form a more comprehensive understanding of how gut microbiota contribute to the adaptive strategies of insects in extreme environments. Collectively, these methodological approaches underscore the importance of microbial symbiosis in enhancing insect resilience under extreme conditions (J. Köhl et al., 2019) (Hongwei Liu et al., 2017). Some researchers emphasize the evolutionary implications of microbiome dynamics, arguing that these microbial communities are subject to selection pressures that can influence host fitness and adaptability (Ayushi Gupta et al., 2020) (Ricardo Cavicchioli et al., 2019). The findings of this literature review reflect a burgeoning field of inquiry into the role of gut microbiota in enabling insect adaptation to extreme environments.

Methodology

To investigate the role of gut microbiota in insect adaptation to extreme environments, this study employed a multi-faceted methodological approach that integrated molecular, experimental, and ecological techniques. The research began with the collection of insect specimens from various extreme environments, including high-altitude regions, arid deserts, and areas with harsh temperature fluctuations. These specimens were then subjected to 16S rRNA gene sequencing to determine the composition and diversity of their gut microbial communities. This sequencing was performed using a PCR amplification protocol involving 35 cycles, with an initial hot starting pre-denaturation temperature of 95°C, followed by annealing at 50°C and elongation at 72°C, to ensure comprehensive coverage of the microbial genomes.In addition to sequencing, metabolic profiling was conducted to analyze the functional changes in the gut bacterial communities. This involved the use of gas chromatography-mass spectrometry (GC-MS) to identify and quantify the metabolites produced by the gut microbiota, providing insights into their metabolic pathways and how these pathways adapt to different environmental conditions. Experimental manipulations of environmental conditions, such as temperature and diet, were also conducted to observe the dynamic responses of the gut microbiota. For instance, insects were exposed to controlled temperature regimes and varied dietary regimens to assess how these changes influence the composition and function of their gut microbial communities.Field-based studies were also undertaken to observe the natural interactions between insects and their gut microbiota in extreme environments. This involved monitoring the physiological and behavioral responses of insects in their natural habitats, using techniques such as mark-release-recapture and observational studies to correlate changes in gut microbiota with environmental stressors. By combining

these methodologies, the study aimed to provide a holistic understanding of how gut microbiota facilitate insect adaptation to extreme environments, highlighting the intricate relationships between host physiology, microbial composition, and environmental factors.

Results

The analysis of gut microbiota in insects exposed to extreme environments revealed significant adaptations that enhance their survival and resilience. For instance, in the ladybird beetle *Micraspis discolor*, the presence of the gut bacterium *Serratia marcescens* (SmMd) was found to be crucial for pollen digestion, a vital nutrient source in resource-scarce environments. Experimental manipulations involving antibiotic treatments and the subsequent reintroduction of SmMd demonstrated a clear correlation between this bacterium and the beetle's ability to utilize pollen, highlighting the symbiotic relationship between the insect and its gut microbiota[4]. Furthermore, 16S rRNA gene sequencing and metabolic profiling of insects from high-altitude and high-temperature environments showed distinct shifts in gut microbial communities. Insects from these environments had a higher abundance of bacteria from the genera *Bacteroides*, *Ruminococcus*, and *Turicibacter*, which are known to enhance nutrient utilization and metabolic efficiency under stressful conditions.Field-based studies and experimental manipulations also indicated that these microbial communities are dynamic and respond to environmental changes. For example, insects subjected to food restriction showed changes in their gut microbiota that favored the breakdown of complex polysaccharides, thereby optimizing nutrient acquisition in resource-poor habitats. These findings underscore the adaptive role of gut microbiota in enabling insects to thrive in extreme environments.

Discussion

The intricate relationships between insects and their gut microbiota have been increasingly recognized as a critical factor in the adaptation of insects to extreme environments. The composition and functional dynamics of gut microbial communities play a pivotal role in enhancing the resilience and survival of insects under various stressors. For instance, specific bacterial genera such as *Bacteroides*, *Ruminococcus*, and *Turicibacter* have been identified as key players in facilitating nutrient utilization and metabolic efficiency in insects exposed to high-altitude and high-temperature environments. These bacteria adapt to environmental changes by enhancing their metabolic pathways, allowing insects to exploit otherwise inaccessible food sources and detoxify harmful substances, thereby promoting survival in harsh habitats. The symbiotic nature of these relationships is further underscored by the observation that certain gut bacteria can modulate the insect's immune response and behavioral adaptations. For example, the gut bacterium *Serratia marcescens* (SmMd) in the ladybird beetle *Micraspis discolor* is essential for pollen digestion, a critical nutrient source in resource-scarce environments. This highlights the specialized roles that gut microbiota can play in enabling insects to thrive in diverse ecological niches.Moreover, the dynamic nature of these microbial communities in response to environmental stressors is a significant aspect of their adaptive function. Field-based studies and experimental manipulations have shown that gut microbiota can shift in composition to favor the breakdown of complex polysaccharides during food restriction, optimizing nutrient acquisition in resource-poor habitats. This adaptability underscores the critical role of gut microbiota in the ecological strategies of insects, particularly in the face of climate change and other environmental stresses. Understanding these complex interactions not only enhances our knowledge of insect biology but also has practical implications for conservation and agricultural practices. By fostering beneficial gut microbiota in crop-pollinating insects, for instance, agricultural productivity and ecological health can be improved. Therefore, continued research into the role of gut microbiota in insect adaptation is essential for developing effective strategies to support biodiversity and ecosystem resilience.

Conclusion

The findings of this dissertation underscore the pivotal role of gut microbiota in enabling insects to adapt to a wide range of extreme environments, from high-altitude ecosystems to harsh temperature regimes and diverse dietary conditions. The intricate relationships between insects and their gut microbes have been elucidated through a comprehensive analysis of microbial composition, functional dynamics, and physiological interactions. The identification of specific bacterial genera such as *Bacteroides*, *Ruminococcus*, and *Turicibacter* as key facilitators of nutrient utilization and metabolic efficiency highlights the specialized roles these microbes play in enhancing insect resilience. Moreover, the dynamic responses of gut microbiota to environmental stressors, as observed through experimental manipulations and field-based studies, emphasize their adaptive function in optimizing nutrient acquisition and detoxification processes.These insights have significant implications for ecological conservation and agricultural practices. By understanding how gut microbiota support insect survival and adaptation,

researchers can develop targeted strategies to foster beneficial microbial communities in crop-pollinating insects, thereby enhancing agricultural productivity and ecosystem health. Additionally, this knowledge can inform conservation efforts aimed at protecting insect species that are crucial for maintaining ecosystem balance, particularly in the face of climate change and other environmental stresses. The integration of these findings into broader ecological and evolutionary frameworks will continue to refine our understanding of the complex interplay between hosts and their microbiota, ultimately contributing to the development of more effective management and conservation strategies.

References

1. Charles J. Mason, IkkeiShikano (2023). "Hotter days, stronger immunity? Exploring the impact of rising temperatures on insect gut health and microbial relationships". 59. pp. 101096-101096. https://doi.org/10.1016/j.cois.2023.101096
2. Ambra Masuzzo, Martina Montanari, C. Léopold Kurz, Julien Royet (2020). "How Bacteria Impact Host Nervous System and Behaviors: Lessons from Flies and Worms". 43. pp. 998-1010. https://doi.org/10.1016/j.tins.2020.09.007
3. Ayushi Gupta, Suresh Nair (2020). "Dynamics of Insect-Microbiome Interaction Influence Host and Microbial Symbiont". 11. https://doi.org/10.3389/fmicb.2020.01357
4. Ricardo Cavicchioli, William J. Ripple, Kenneth N. Timmis, Farooq Azam, Lars R. Bakken, Matthew Baylis, Michael J. Behrenfeld, Antje Boëtius, Philip W. Boyd, Aimée T. Classen, Thomas W. Crowther, Roberto Danovaro, Christine M. Foreman, Jef Huisman, David A. Hutchins, Janet Jansson, David M. Karl, Britt Koskella, David B. Mark Welch, Jennifer B. H. Martiny, Mary Ann Moran, Victoria J. Orphan, David Reay, Justin V. Remais, Virginia I. Rich, Brajesh K. Singh, Lisa Y. Stein, Frank J. Stewart, Matthew B. Sullivan, Madeleine J. H. van Oppen, Scott C. Weaver, Eric A. Webb, Nicole S. Webster (2019). "Scientists' warning to humanity: microorganisms and climate change". 17. pp. 569-586. https://doi.org/10.1038/s41579-019-0222-5
5. Nina Montoya?Ciriaco, Selene Gómez-Acata, Ligia Catalina Muñoz-Arenas, Luc Dendooven, Arturo Estrada?Torres, Aníbal H. Díaz de la Vega?Pérez, Yendi E. Navarro-Noya (2020). "Dietary effects on gut microbiota of the mesquite lizard Sceloporus grammicus (Wiegmann, 1828) across different altitudes". 8. https://doi.org/10.1186/s40168-020-0783-6
6. Claudio Franceschi, Paolo Garagnani, Paolo Parini, Cristina Giuliani, Aurelia Santoro (2018). "Inflammaging: a new immune-metabolic viewpoint for age-related diseases". 14. pp. 576-590. https://doi.org/10.1038/s41574-018-0059-4
7. Denis Faure, Jean?Christophe Simon, Thierry Heulin (2018). "Holobiont: a conceptual framework to explore the eco?evolutionary and functional implications of host-microbiota interactions in all ecosystems". 218. pp. 1321-1324. https://doi.org/10.1111/nph.15199
8. J. Köhl, Rogier Kolnaar, Willem J. Ravensberg (2019). "Mode of Action of Microbial Biological Control Agents Against Plant Diseases: Relevance Beyond Efficacy". 10. https://doi.org/10.3389/fpls.2019.00845
9. Hongwei Liu, Lília C. Carvalhais, Mark Crawford, Eugenie Singh, Paul G. Dennis, Corné M. J. Pieterse, Peer M. Schenk (2017). "Inner Plant Values: Diversity, Colonization and Benefits from Endophytic Bacteria". 8. https://doi.org/10.3389/fmicb.2017.02552
10. Samiran Banerjee, Marcel G. A. van der Heijden (2022). "Soil microbiomes and one health". 21. pp. 6-20. https://doi.org/10.1038/s41579-022-00779-w
11. Tobin J. Hammer, Eli Le, A.N. Martin, Nancy A. Moran (2021). "The gut microbiota of bumblebees". 68. pp. 287-301. https://doi.org/10.1007/s00040-021-00837-1
12. Samuel Latour, Grégoire Noël, Laurent Serteyn, Abdoul Razack Sare, Sébastien Massart, Frank Delvigne, Frédéric Francis (2021). "Multi-omics approach reveals new insights into the gut microbiome of Galleria mellonella (Lepidoptera:Pyralidae) exposed to polyethylene diet". https://doi.org/10.1101/2021.06.04.446152
13. Alma, Alberto, Balloi, Annalisa, Bandi, Claudio, Cherif, Ameur, Crotti, Elena, Daffonchio, Daniele, Favia, Guido, Gonella, Elena, Hamdi, Chadlia, Marzorati, Massimo, Sansonno, Luigi (2012). "Microbial symbionts : a resource for the management of insect-related problems". 'Wiley'. https://core.ac.uk/download/55756107.pdf
14. del Castillo, Erika, Izard, Jacques (2015). "Metagenomics for Bacteriology". Digital Commons@University of Nebraska - Lincoln. https://core.ac.uk/download/286364305.pdf

"Smart Materials and Their Applications: Innovations and Their Influence on Today's World"

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Abstract -

Smart materials have revolutionized solutions by offering unique properties that can respond dynamically to external stimuli, enabling innovative solutions across various sectors. This abstract explores the transformative impact of smart materials and their diverse applications in science , engineering and technology disciplines. Smart materials exhibit adaptive behaviors in response to environmental changes, such as temperature, stress, or electromagnetic fields. These materials encompass a wide range of substances, including shape memory alloys, piezoelectric materials, and self-healing polymers, each with specific functionalities that enhance performance and functionality in different applications. Collaborations between chemical engineers, materials scientists, computational experts, and environmental specialists facilitate the development of integrated solutions for challenges such as carbon capture, renewable energy integration, and sustainable chemical synthesis. This collaborative approach not only fosters innovation but also ensures that technological advancements align with societal and environmental sustainability goals. In aerospace engineering, smart materials contribute to lightweight structures, active vibration control, and morphing wing designs, improving aerodynamic performance and fuel efficiency. Moreover, in biomedical engineering, smart materials are used in implants, drug delivery systems, and tissue engineering scaffolds, where their biocompatibility and responsiveness enable precise therapeutic interventions and tissue regeneration. Interdisciplinary collaboration between material scientists, engineers, and biomedical researchers is crucial for advancing smart materials. Technology has an important role to play in the development of a sustainable society, and technical research is fundamental to ensure the advancement of technologies that is required to achieve the needed progress in eco-efficiency and social performance of future technologies. Together, they innovate new materials, optimize manufacturing processes, and integrate smart functionalities into existing and emerging technologies. In conclusion, smart materials represent a paradigm shift in material science and technology, offering capabilities to enhance functionality, efficiency, and safety across diverse applications. By leveraging the unique properties of smart materials and fostering interdisciplinary collaboration, engineers continue to push the boundaries of innovation and create transformative solutions for societal challenges.

Key Words: Smart materials, Self-healing polymers, Environmental specialists, Aerospace engineering, Biomedical engineering.

1. INRODUCTION -

Smart materials represent a category of advanced materials that have revolutionized science, engineering and technology practices by offering unique properties and capabilities that respond dynamically to external stimuli. This introduction explores the transformative impact of smart materials in various production disciplines, highlighting their diverse applications and potential to enhance functionality, efficiency, and safety across industries. Smart materials are characterized by their ability to adapt their properties in response to changes in their environment, such as temperature, stress, light, magnetic fields, or pH levels. These materials exhibit inherent functionalities that enable them to perform tasks beyond the capabilities of traditional materials, making them highly sought after in fields ranging from advance material and aerospace engineering to biomedical applications. These smart materials play a crucial role in structural and health monitoring systems. Embedded sensors in concrete structures or bridges made from piezoelectric materials can detect changes in stress or strain, providing real-time data on structural integrity and potential damage. This proactive monitoring helps prevent disastrous failures, reduce maintenance costs, and extend the life span of infrastructure. In Aerospace manufacturing works leverages smart materials for their lightweight properties and ability to withstand high-stress

conditions. Shape memory alloys, for instance, are used in actuators for morphing wing designs that optimize aerodynamic performance and fuel efficiency. Additionally, smart materials enable active vibration control systems that mitigate vibrations and noise in aircraft, improving passenger comfort and safety. In biomedical engineering, smart materials are integrated into medical devices, implants, and tissue engineering scaffolds. Biocompatible polymers with shape memory properties are used in stents that expand within blood vessels, while drug-eluting coatings on implants release medications locally to improve therapeutic outcomes. These materials also support advancements in regenerative medicine by providing scaffolds that mimic natural tissue environments and promote cell growth. Interdisciplinary collaboration between material scientists, engineers, and biomedical researchers drives innovation in smart materials. Researchers work together to develop new materials, enhance manufacturing techniques, and explore novel applications that address complex engineering challenges. This collaborative approach not only accelerates technological advancements but also ensures that smart materials meet rigorous safety, reliability, and performance standards. Thus, smart materials represent a transformative frontier in engineering, offering capabilities that enhance functionality, efficiency, and safety across diverse applications. By harnessing the unique properties of smart materials and fostering interdisciplinary collaboration, engineers are poised to continue pushing the boundaries of innovation and creating impactful solutions for societal and technological challenges.

2. LITERATURE SURVEY-

Overview of Smart Materials:

Smart materials are defined by their ability to respond to external stimuli with adaptive behavior, such as changes in temperature, stress, or electromagnetic fields (Boller & Chang, 2013). These materials encompass various types, including shape memory alloys (SMAs), piezoelectric materials, magnetostrictive materials, and polymers with self healing properties (Wei & Shuler, 2009). Applications in Civil Engineering: In civil engineering, smart materials are employed for structural health monitoring (SHM) to detect and assess damage in infrastructure such as bridges and buildings (Farrar et al., 2001). Sensors embedded in concrete structures or composites enable real-time monitoring of stress, strain, and structural integrity, enhancing safety and reducing maintenance costs (Ciang et al., 2018). Aerospace Engineering Applications: Smart materials contribute significantly to aerospace applications, including morphing wing designs and active vibration control systems (Balaji & Hariharan, 2016). Shape memory alloys (SMAs) are utilized in actuators for adaptive wing structures that optimize aerodynamic performance and fuel efficiency (Padmanabhan & Gurusamy, 2014). Biomedical Engineering and Healthcare Applications: In biomedical engineering, smart materials play a crucial role in medical devices and implants, such as shape memory polymers in stents for minimally invasive surgery (Lendlein & Langer, 2002). These materials also support drug delivery systems, tissue engineering scaffolds, and biocompatible coatings on implants to enhance therapeutic outcomes and patient care (Hench & Polak, 2002). Interdisciplinary Collaboration and Innovations: Advances in smart materials often result from interdisciplinary collaboration between material scientists, engineers, and biomedical researchers (Rao et al., 2015). Collaborative efforts focus on developing novel materials, improving manufacturing processes, and exploring innovative applications that address complex engineering and healthcare challenges (Schneider et al., 2017). Challenges and Future Directions: Challenges in smart materials research include scalability, durability, and cost effectiveness for widespread commercial applications (Atkinson, 2018). Future directions involve enhancing material properties, integrating advanced functionalities, and exploring new applications in renewable energy, environmental monitoring, and consumer electronics (Yang et al., 2020). This literature survey provides an overview of the current state of research and applications in smart materials across engineering disciplines, highlighting their impact, challenges, and future prospects. Each area of application underscores the transformative potential of smart materials in enhancing functionality, efficiency, and sustainability in various technological and biomedical fields.

3. KEY FINDINGS AND STRATEGIES - Several potential applications of smart materials in different sectors and industries are also reviewed starting from engineering to the present environment Here are the key findings and strategies related to smart materials and their applications in science and technology :

Key Findings:

1. Versatile Applications: Smart materials exhibit diverse applications across engineering disciplines, including civil, aerospace, and biomedical engineering. They are utilized for structural health monitoring, adaptive structures, active vibration control, and biomedical devices.

2. Enhanced Functionalities: These materials possess unique properties such as shape memory, piezoelectricity, and self-healing capabilities. These functionalities enable them to respond dynamically to external stimuli, contributing to improved performance and efficiency in various applications.
3. Interdisciplinary Collaboration: Advancements in smart materials often result from collaborative efforts between material scientists, engineers, and biomedical researchers. This interdisciplinary approach fosters innovation in material development, manufacturing techniques, and application design.
4. Safety and Reliability: Smart materials enhance safety and reliability in engineering applications by providing real-time monitoring of structural integrity, reducing maintenance costs, and enhancing operational efficiency.
5. Future Directions: Future research directions focus on improving scalability, durability, and cost-effectiveness of smart materials for broader commercial adoption. Exploration of new applications in renewable energy, environmental monitoring, and consumer electronics is also emphasized.

Strategies:

1. Development of Novel Materials: Invest in research and development to create new smart materials with enhanced functionalities and improved performance characteristics tailored to specific engineering needs.
2. Optimization of Manufacturing Processes: Refine manufacturing techniques to scale up production of smart materials while maintaining quality, consistency, and cost-effectiveness.
3. Integration into Engineering Design: Incorporate smart materials early in the engineering design process to leverage their unique properties for optimized performance and functionality.
4. Continuous Innovation and Collaboration: Foster a culture of innovation and collaboration across disciplines to explore new applications, improve existing technologies, and address emerging challenges in engineering and healthcare.
5. Regulatory Compliance and Standards: Adhere to reg ulatory standards and safety protocols to ensure the reliability, durability, and safety of smart materials in commercial applications.
6. Education and Training: Promote education and training programs to equip engineers and researchers with the skills and knowledge required to effectively utilize and innovate with smart materials in diverse engineering fields. By implementing these strategies and leveraging the key findings from research, engineers and researchers can effectively harness the transformative potential of smart materials to advance engineering practices, improve sustainability, and drive innovation across industries.

4. CONCLUSION -

Smart materials represent a paradigm shift in engineering, offering unprecedented capabilities to respond dynamically to external stimuli and enhance functionality across diverse applications. This conclusion synthesizes key findings and strategies from the exploration of smart materials in engineering disciplines, underscoring their transformative impact and future potential. Smart materials, such as shape memory alloys, piezoelectric materials, and self-healing polymers, exhibit unique properties that enable adaptive behaviors crucial for various engineering applications. In civil engineering, these materials are integral to structural health monitoring systems, providing real-time data on infrastructure integrity and reducing maintenance costs. Aerospace applications benefit from lightweight structures and active vibration control systems, enhancing aerodynamic performance and fuel efficiency. In biomedical engineering, smart materials support advancements in medical devices, implants, and drug delivery systems, improving patient care and therapeutic outcomes. Interdisciplinary collaboration plays a vital role in advancing smart materials, facilitating innovation in material development, manufacturing techniques, and application design. By fostering collaborations between material scientists, engineers, and biomedical researchers, new materials are developed, and existing technologies are optimized to address complex engineering challenges effectively. Strategies for advancing smart materials include continuous innovation, optimization of manufacturing processes, integration into engineering design, and adherence to regulatory standards. Education and training programs are crucial for preparing engineers and researchers to harness the full potential of smart materials and drive future advancements. Looking ahead, future research aims to enhance scalability, durability, and cost-effectiveness of smart materials for broader commercial adoption. Exploration of new applications in renewable energy, environmental monitoring, and consumer electronics holds promise for expanding the impact of smart materials in addressing global challenges.

REFERENCE -

1. Balaji, S., & Hariharan, R. (2016). Application of Shape Memory Alloys in Aerospace. Materials Today: Proceedings, 3(10), 3767-3773.
2. Boller, C., & Chang, F. K. (Eds.). (2013). Smart Technologies for Safety Engineering. John Wiley & Sons.
3. Ciang, C. C., et al. (2018). Structural Health Monitoring of Civil Infrastructure Using Smart Materials: A Review. Structural Health Monitoring, 17(1), 38-57.
4. Farrar, C. R., et al. (2001). Overview of Piezoelectric Impedance-based Health Monitoring and Path Forward. The Shock and Vibration Digest, 33(3), 269-280.
5. Hench, L. L., & Polak, J. M. (2002). Third-generation biomedical materials. Science, 295(5557), 1014-1017.
6. Lendlein, A., & Langer, R. (2002). Biodegradable, Elastic Shape-Memory Polymers for Potential Biomedical Applications. Science, 296(5573), 1673-1676.
7. Padmanabhan, P., & Gurusamy, R. (2014). Review on Shape Memory Alloys. International Journal of Innovative Research in Science, Engineering and Technology, 3(4), 10353-10359.
8. Rao, C. N. R., et al. (2015). Nanostructures and Nanomaterials: Synthesis, Properties, and Applications. World Scientific Publishing Co. Pte Ltd.
9. Schneider, J., et al. (2017). Progress in Polymer Science. Progress in Polymer Science, 69, 1-48.
10. Kumar, Avinash, Anka Datta, Ashwani Kumar, and Abhishek Kumar. "Recent advancements and future trends in next-generation materials for biomedical applications." In Advanced materials for biomedical applications, pp. 1-19.
11. Kumar, Avinash, Anka Datta, Ashwani Kumar, and Abhishek Kumar. "Recent advancements and future trends in next-generation materials for biomedical applications." In Advanced materials for biomedical applications, pp. 1-19.
12. Kumar, Avinash, Anka Datta, Ashwani Kumar, and Abhishek Kumar. "Recent advancements and future trends in next-generation materials for biomedical applications. " In Advanced materials for biomedical applications, pp. 1-19.
13. Kumar Dr. Rakesh, et al. (2005). Applications of Smart Materials ,ICI journal; pp. 15-18;
14. Mishra, A.K., et al. (2016). Smart materials for waste water applications 23-26
15. Diego Galar, et al. (2017). "Chapter 8 - Actuators and Self-Maintenanc Approaches," Maintenance, pp. 475-527
16. Li Jingcheng et al (2021), "Intelligent Polymers, Fibers and Applications," Polymers, vol. 13, no. 9, pp. 1-19
14. Abdulkadir Cüneyt Aydin, et al (2023) and O?uzhan Çelebi?, "Piezoelectric Materials in Civil Engineering Applications: A Review," ACS Omega, vol. 8, no. 22, pp. 19168-19193.
15. Wenjie Wang et al., (2023) , "Development and Prospect of Smart Materials and Structures for Aerospace Sensing Systems and Applications," Sensors, vol. 23, no. 3, pp. 1-28

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