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Vibha विज्ञान भारती

ABSTRACT BOOK

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ENVIRONMENTAL SUSTAINABILITY, CLIMATE ADAPTATION & DISASTER MANAGEMENT - 2026

ESCAD-2026

Organized on the occasion of

International Day for

BIOLOGICAL DIVERSITY

and

WORLD ENVIRONMENT DAY

ORGANIZED BY

Department of Environmental Science,
School of Earth and Environmental Sciences,
Central University of Himachal Pradesh
(Shahpur Campus) 176206

In collaboration with

Vijnana Bharati

Sponsored by ANRF

21st -22nd May, 2026

VENUE:
Central University of HP,
Shahpur Campus

विश्वविद्यालय कुलगीत

देव धरा चिन्तन में वीर भूमि रक्षण में
स्थित धवल धर अंचल में,
ज्ञान ज्योति आलोक समुज्ज्वल ।
केंद्रीय विश्वविद्यालय हिमाचल ।।

विज्ञान कला का अर्जन स्वविस्तार का सच है ।
कौशल विकास का शिक्षण जीवन का गतिक्रम है ।।
प्रेरक ऊर्जा युम्फित पलपल ।-
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अनुसन्धान पर केन्द्रित शोध और आलेखन ।
प्रश्नाकुल मेधा का समसययक निर्देशन ।।
अध्ययन मनन अर्जित श्रम फल ।
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मन पाटी पर अंकित संस्कारों की थाती ।
अभियान मुखी पंखों को दिशाबोध आश्वास्ति ।।
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हिमाचल, हिमाचल, हिमाचल, हिमाचल ।।

Prof. Sat Prakash Bansal,
Chief Patron, ESCAD-2026
&
Vice Chancellor, Central University of Himachal Pradesh (CUHP), Dharamshala

Message

It is with immense pride and a deep sense of responsibility that I extend my warm greetings to all participants of the 2nd International Conference on Environmental Sustainability, Climate Adaptation & Disaster Management (ESCAD-2026), to be held on 21–22 May 2026 at the CUHP, Shahpur Campus.

This important conference is being organised on occasion of the International Day for Biological Diversity and World Environment Day, reflecting our collective commitment towards environmental protection, climate resilience, and sustainable development. The themes "Acting Locally for Global Impact" and "Climate Action (#NowForClimate)" highlight the urgent need for collaborative action in addressing global environmental challenges through local and regional initiatives.

In the present era, the impacts of climate change, environmental degradation, biodiversity loss, pollution, and disaster risks are becoming increasingly severe, particularly in ecologically sensitive regions such as the Himalayas. Therefore, there is an urgent need for scientific innovation, interdisciplinary research, and policy-driven solutions to ensure a sustainable and resilient future.

ESCAD-2026 provides an excellent platform for academicians, researchers, policymakers, industry experts, and students from across the globe to exchange ideas, share scientific advancements, and deliberate upon practical strategies for environmental sustainability and disaster preparedness. I am confident that the deliberations and recommendations emerging from this conference will contribute significantly at both national and global levels.

I sincerely appreciate the organising committee's dedicated efforts in curating such a prestigious academic event. I hope that all participants will have a productive and inspiring experience during the conference.

I extend my best wishes for the grand success of ESCAD-2026.

Prof. Narender Sankhayan,
Patron, ESCAD-2026
&
Registrar, *Central University of Himachal Pradesh (CUHP), Dharamshala*

Message

It gives me great pleasure to extend my warm greetings to all participants of the 2nd International Conference on Environmental Sustainability, Climate Adaptation & Disaster Management (ESCAD-2026), being organised on 21–22 May 2026 at the Shahpur Campus of the Central University of Himachal Pradesh.

The conference is being organised at a time when global attention is increasingly focused on environmental conservation, biodiversity protection, and urgent climate action, emphasising the importance of local initiatives in addressing worldwide environmental challenges. Environmental sustainability, climate resilience, biodiversity conservation, and disaster preparedness have become global priorities. In ecologically sensitive regions such as the Himalayas, scientific research, innovation, and collaboration are essential for ensuring sustainable development and environmental protection.

ESCAD-2026 will provide an excellent platform for researchers, academicians, policymakers, industry experts, and students to exchange ideas, share scientific advancements, and discuss sustainable solutions for environmental challenges, including climate change adaptation, disaster risk reduction, environmental monitoring, pollution control, bioremediation, nanoscience and energy applications, environmental health, and sustainable waste management. I appreciate the organising committee's efforts in organising this important academic event.

I extend my best wishes for the grand success of ESCAD-2026 and wish all participants a productive and enriching experience.

Prof. Deepak Pant,
Chairman, ESCAD–2026
&
Dean, School of Earth and Environmental Sciences, CUHP, Dharamshala

Message

It gives me immense pleasure to welcome all the distinguished delegates, researchers, academicians, scientists, industry experts, and students to 2nd International Conference on Environmental Sustainability, Climate Adaptation & Disaster Management (ESCAD-2026), organised by Department of Environmental Sciences, School of Earth & Environmental Sciences, Central University of Himachal Pradesh (CUHP), at Shahpur Campus on 21–22 May 2026.

The conference aligns with two major environmental days, i.e., International Day for Biological Diversity (22nd May 2026) and World Environment Day (6th June 2026). This year, the themes are highly relevant "Acting Locally for Global Impact" and "Climate Action (#NowForClimate)" to today's context, where the world is witnessing unprecedented environmental challenges, climate variability, natural disasters, and increasing pressure on ecological systems. I strongly believe that academic excellence and impactful research must go hand in hand to foster innovation, critical thinking, and evidence-based decision-making.

ESCAD-2026 aims to provide a vibrant interdisciplinary platform for intellectual exchange and collaborative dialogue on contemporary environmental issues, with a particular focus on the thematic areas mentioned. I am confident that the technical sessions, invited lectures, and scientific interactions during this conference will inspire new ideas, strengthen research collaborations, and contribute meaningfully toward sustainable environmental management and climate resilience.

The exchange of knowledge and experiences among participants will certainly pave the way for innovative solutions to emerging environmental concerns. I congratulate the organising committee for their sincere efforts in arranging this important international conference and wish all participants a highly enriching and successful experience.

I wish ESCAD-2026 a grand success.

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AI-Assisted IoT-Integrated Graphene-Based Gas Sensor Network Towards Disaster-Prone and Environmentally Sensitive Zones

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The continuous occurrence of environmental disasters, industrial outflows, landfill releases and geogenic instabilities may produce harmful gasses, highly inauspicious to eco-systems and public wellbeing. The present study introduces an AI powered Internet of Things (IoT) permitted smart gas sensor network. For these networks, Graphene-based gas sensors are good candidates because of their fast response time, ultra-high surface sensitivity, and low threshold for adsorption of gas traces. These networks combine graphene-based nanomaterial sensing interfaces, useful for the real-time watching and early findings of toxic atmospheric emissions for instance nitrogen dioxide (NO_2), hydrogen sulphide (H_2S), methane (CH_4), and oxygen depletion events. The innovative approaches of these networks allow us to collect the data regarding the concentrations of various harmful gases in the environment. One may fix these networks in environmental disaster-prone areas and collect desired data or prior information before any mishap. The automatic early warning capabilities of these networks environment sensitive zones and disaster-prone areas for instance garbage disposal sites, mining area, landscape prone areas or earthquakes, industrial area, sewage systems, etc., may control many mishaps for human well-being. The combination of nanotechnology, AI, and IoT is pioneering, sustainable, and smart approach towards the future environmental hazard watching and disaster management.

Leveraging the Role of Technologies for Prevention and Mitigation of Environmental Disaster: A Study of Legal Framework in India

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Environmental disaster like floods, landslides, forest fire, industrial pollution, chemical spills and climatic hazards have increasing drastically. It has posed the severe and significant threat to human being, ecological balance and sustainable development. The emerging technologies involving artificial intelligence, (AI) GIS, remote sensing, satellite monitoring, drone technology and early warning systems have grown up as effective instrument for disaster preparedness, mitigation and prevention. In real-world these technologies assisting to the individual and authorities for monitoring risk assessment, environment pollution detection and sudden emergency response methods. Current study examines the use of emerging technologies in preventing and mitigating the environmental disaster in India with special reflection to existing legal and institutional framework. The study critically analyses the provisions of the Disaster Management Act 2005, Environment (Protection) Act 1986, policies and plans of NDMA, and other environmental provisions which governing the disaster management and technological interventions. This paper showed the challenges regarding the technological accessibility, data governance, proficiency of officials, environmental justice and implementation gaps within the Indian disaster governance system. This study adopted an analytical approach by analyzing statutory laws, judgements, governmental policies, departmental reports and other secondary literature. It has also revealed that while India has progressively integrated technological advancement into disaster management and environmental legal frameworks, comprehensive lacunae exist in the present legal and regulatory frameworks regarding cooperation, responsibilities, transparency and sustainable technological implementation. It illustrates for capacity building, policy resiliency and advance technological transformation systems to robust the disaster preparedness, prevention and mitigation in India.

Landfill Site Selection in the Himalayan Region using Google Earth Engine and CPHEEO-Based Boolean Logic: A Case Study of Himachal Pradesh

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The current study presents the integration of cloud-based geographical information systems (GIS) and Boolean Logic elimination techniques for municipal landfill site selection, a case example in Himachal Pradesh, India. In the first step, useful criteria were determined based on the literature review, Central Public Health and Environmental Engineering Organization (CPHEEO) guidelines, and regional Himalayan characteristics. Several criteria including distance from surface water, slope, topographic wetness index (TWI), distance from settlements, land cover, and soil clay content were selected, and a constraint-based structure was formed for landfill suitability. The maps of the criteria were processed using the Google Earth Engine (GEE) platform. Using strict binary thresholding, the maps were standardized to exclude environmentally sensitives zones. A Boolean Logic screening approach was applied to overlay the parameter layers, effectively masking out restricted areas to gain the final landfill suitability map in the study area. The final map was assorted into two distinct classes, i.e., suitable and unsuitable regions. The result indicates that 97% of the study area is inappropriate and cannot be considered as a landfill due to sleep topography and forest cover. A district-level statistical analysis was performed for further assessment, identifying specific viable zones in lower-altitude districts. The result illustrated that an integrating approach of GEE and regulatory-based logic is effective in landfill site selection.

Temporal Analysis of Urbanization and Nitrogen Dioxide (NO2) Levels in Shimla (2014-2024) using Google Earth Engine

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Rapid urban growth in the ecologically sensitive Himalayan hill stations significantly changes land cover and air quality. This study provides a clouds-based analysis of urban expansion and levels of nitrogen dioxide (NO_2) in the troposphere over Shimla, Himachal Pradesh, India, 2014 to 2024, completed entirely in Google Earth Engine (GEE). We used Landsat 8 OLI/TIRS Collection-2 surface reflectance composites to create annual Normalized Difference Built-up Index (NDBI) and Normalized Difference Vegetation Index (NDVI) maps for a 10 km radius study area. In 2024, we analyzed Sentinel-5P TROPOMI tropospheric NO_2 column number density data to examine seasonal air quality patterns. The results indicate a roughly 50% increase in built-up area (from 18.4 to 27.6km2) and about a 12.9% decline in forest cover (from 124 to 108 km2) over the decade. Monthly NO_2 levels peak during winter (November to January) at values 2.5 to 2.8 times higher than the minimum seen during the monsoon, largely due to thermal inversions. The highest levels of NO_2 coincide with the densest urban core, consistent with vehicle traffic and combustion sources being significant contributors to air quality pressures in this narrow mountain valley.

Keywords: Nitrogen Dioxide, Google Earth Engine (GEE), Normalized Difference Built-up Index (NDBI) and Normalized Difference Vegetation Index (NDVI)

Differential Gene Expression Analysis of Microplastic Exposure In Humans

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Microplastics have become a major environmental issue due to their widespread presence and their severe impact on human health. Continuous exposure to Polystyrene microplastics via different routes alters the expression of genes related to metabolic function and inflammation, predominantly affecting liver, gut, and skin outcomes. The scant literature on microplastic toxicity and related pathologies prompts researchers worldwide to gain a better understanding of its cellular and molecular mechanisms, thereby enabling operational plans to safeguard both environmental and human health. Therefore, this study aimed to identify differentially expressed genes (DEGs) in available gene expression datasets of skin (GSE255709) and liver (GSE237738) after significant exposure to microplastics. We obtained data from the GEO database and analyzed them to identify DEGs using the GEO2R online tool with statistical criteria (Adjusted p-value < 0.05 and log2 fold change> 1 or <- 1), as marked significant change. The results showed a total of 392 significant DEGs in skin samples, including 159 upregulated and 233 downregulated genes. Moreover, in the liver, we identified 341 DEGs, of which 88 and 253 were upregulated and downregulated, respectively, via transcriptomic analysis. After validation in uniport database the skin showed 120 upregulated and 192 downregulated valid entry genes, while liver samples showed 226 downregulated and 97 upregulated valid gene entries. The results showed that microplastic exposure significantly alters the expression of selected genes, with the most prominent changes observed. In liver samples, these included CYP3A4, MMP15, and DUSP10, while in skin samples, notable changes were observed in CYP2C19 and CYP3A4. These finding suggest a major disturbance in xenobiotic detoxification, cellular stress mechanism, inflammatory pathways, extracellular matrix restructure, and lipid metabolism. This finding provides a foundation for future research, by offering a better understanding of the molecular impact of microplastic exposure, discovery of biomarkers, and supporting the development of preventive and therapeutic interventions.

Insight into Molecular Interactions of Antidiabetic Drug Metformin Hydrochloride with Sorbitol in Aqueous Medium

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Density (ρ), speed of sound (u) and viscosity (η) measurements were carried out to examine the drug (Metformin Hydrochloride)-Carbohydrate (sorbitol) interactions in aqueous medium. The experimental values of density (ρ), speeds of sound (u) and relative viscosities (η) of Metformin Hydrochloride (MH) in water and in 2, 4 and 6% aqueous sorbitol have been obtained at different temperatures (305.15, 310.15 and 315.15) K and at 0.1MPa pressure. The experimental ρ and u data have utilized to calculate the various thermodynamic parameters such as apparent molar volume (Φ_V), apparent molar isentropic compression(Φ_K), limiting apparent molar volume(Φ^o), limiting apparent molar isentropic compression (Φ^o), limiting apparent molar expansibility $(\Phi^o)_{KE}$ of solute, thermal expansion coefficient(α^o), limiting apparent molar volume of transfer ($\Delta_{tr}\Phi^o$) and limiting apparent molar isentropic compression of transfer ($\Delta_{tr}\Phi^o$) for MH in water and aqueous sorbitol solutions. The viscosity data have been utilized to determine Falkenhagen Coefficient (A), Jones-Dole coefficient (B), the temperature derivative of Jones-Dole coefficient (dB/dT). A detailed discernment into the physicochemical interactions e.g., hydrophilic-hydrophilic, hydrophilic-hydrophobic and hydrophobic-hydrophobic interactions in the drug-carbohydrate system together with the structure-making/breaking tendency of drug have been redeemed through the scrutiny of above calculated parameters.

Integrated Clean Water and Green Hydrogen Production Using Flexible π-Conjugated COF Films

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The growing demand for clean water and sustainable energy has created an urgent need for advanced multifunctional materials capable of addressing both environmental remediation and renewable fuel production. This research focuses on the design and development of flexible π-conjugated covalent organic framework (f-COF) films for simultaneous water purification and hydrogen generation through artificial photosynthesis. The research aims to tackle two major global challenges: the removal of emerging contaminants from wastewater and the production of clean hydrogen fuel under solar irradiation. The proposed work involves the interfacial synthesis of highly ordered imine-linked f-COF films using donor–acceptor chromophore systems. Amine-functionalized porphyrin (PTTA) and aldehyde-functionalized bipyridine (BPyAld) will undergo Schiff-base condensation at liquid–liquid interfaces, leading to the formation of self-standing, flexible, and porous two-dimensional frameworks with tunable optoelectronic properties. Structural and physicochemical properties of the synthesized materials will be thoroughly characterized using XRD, TEM, AFM, XPS, BET, UV–Vis, and other spectroscopic techniques. The photocatalytic activity of the f-COF films will be evaluated for the degradation of antibiotics, pesticides, and endocrine-disrupting pollutants in both synthetic and real wastewater systems. HPLC and TOC analyses will be employed to determine degradation efficiency and identify reaction intermediates. In parallel, the films will be explored for photoelectrochemical hydrogen evolution under visible-light irradiation. Electrochemical analyses, including cyclic voltammetry, electrochemical impedance spectroscopy, and photocurrent measurements, will provide insights into charge separation and transfer mechanisms. Mechanistic studies will investigate the generation of reactive oxygen species and their role in pollutant degradation. Additionally, the stability, recyclability, and scalability of the f-COF films will be assessed. This integrated approach is expected to advance the development of efficient, durable, and multifunctional photocatalysts for sustainable environmental remediation and clean energy production.

Solvent-Programmable Multicolor 2D Bismuth–Perylene Hybrid Nanosheets for the Multimodal Fluorescent Detection of Cadmium and Ammonia in Aquatic Systems

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The integration of emerging functional materials into chemical engineering systems is critical for advancing next-generation sensing, environmental monitoring, and process control technologies. Herein, we report a solvent-programmable two-dimensional bismuth–perylene tetracarboxylic acid hybrid (PTCA-Bi) that functions as a multifunctional luminescent platform for selective detection of ammonia and cadmium in aqueous and organic environments. The material is constructed via controlled coordination of Bi^{3+} ions with PTCA, yielding a stable 2D nanosheet architecture in which metal-ligand orbital hybridization governs solvent-dependent photophysical behavior. In organic media, PTCA-Bi exhibits strong yellow emission, which is selectively quenched by Cd^{2+} through a photoinduced electron transfer pathway, enabling

ultrasensitive detection, well below World Health Organization limits for drinking water. In contrast, in aqueous media the nanosheets undergo aggregation-induced quenching, yet regain intense bluish green fluorescence upon NH_3 exposure, driven by hydrogen-bond-mediated charge redistribution and nanosheet assembly. Density functional theory calculations reveal thermodynamically favorable coordination and solvent-dependent frontier orbital reorganization consistent with metal-to-ligand charge-transfer transitions. Importantly, the sensor demonstrates accurate and reproducible detection of Cd^{2+} and NH_3 in river water, tap water, and wastewater samples, underscoring its practical applicability. The PTCA–Bi nanosheets exhibit high selectivity, robustness, and environmental compatibility, highlighting their promise for real-world monitoring of hazardous contaminants in aquatic systems.

Conservation and Sustainable Use of Biodiversity for Climate Change Adaptation

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Biodiversity is fundamental to ecosystem functioning and plays a crucial role in supporting human well-being, particularly in the context of climate change. The conservation and sustainable use of biodiversity are essential strategies for enhancing resilience and enabling adaptation to changing environmental conditions. Diverse ecosystems such as forests, wetlands, and grasslands provide vital ecosystem services, including carbon sequestration, water regulation, soil fertility, and protection against extreme weather events. However, rapid biodiversity loss driven by human activities such as deforestation, urbanization, pollution, and overexploitation has significantly weakened ecosystem resilience. This decline reduces the capacity of natural systems and communities to adapt to climate variability and increases vulnerability to environmental risks. Sustainable practices such as ecosystem-based adaptation, habitat restoration, agroforestry, and conservation of natural resources can effectively address these challenges. Incorporating indigenous and local knowledge into conservation strategies enhances adaptive capacity and promotes sustainable resource management. Strong policy frameworks, public awareness, and community participation are critical for ensuring long-term success. Protecting biodiversity hotspots and restoring degraded ecosystems are vital steps toward achieving climate resilience. In conclusion, biodiversity conservation is a cost-effective and sustainable approach to climate change adaptation. It not only safeguards ecological balance but also supports livelihoods and ensures environmental sustainability for future generations.

A Comprehensive Review of *Hedychium flavescens* Carey ex Roscoe

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Hedychium flavescens Carey ex Roscoe (Zingiberaceae), a robust perennial rhizomatous herb native to the eastern Himalayas, including northeast India and Nepal, is also referred to as yellow ginger, cream ginger lily, or cream garland lily. Populations of this species are found in Northeast and South India, occurring primarily in tropical to warm-temperate climates. From an ethnobotanical perspective, *H. flavescens* holds immense cultural and medicinal significance. The Dongria Kondh tribes use a paste made from its rhizomes to treat sprains, joint inflammation, arthritic pain, eczema, itching, and skin infections; they refer to it as "Penu Ada". The essential oil of *H. flavescens* rhizomes is primarily made up of monoterpene hydrocarbons and oxygenated monoterpenes. Various studies have reported numerous phytochemicals in its essential oil, with β-pinene, linalool, 1,8-cineole, and α-pinene being the major constituents. These phytochemicals possess pharmacological activities such as antibacterial, antioxidant, anti-inflammatory, and anti-cancer properties. Recent studies have investigated its anti-cancer activity against various human cancer cell lines such as MCF-7, HeLa, A549, and HepG2, primarily through apoptosis induction, increased ROS generation, and cell cycle arrest. Furthermore, it also exhibits antidiabetic activity, which has been evaluated using alloxan and streptozotocin induced diabetic animal models. Although some studies have investigated the phytochemical profile and biological activities of *H. flavescens*, its potential has not yet been fully studied. Therefore, the objective of this study is to highlight the significance of this plant, focusing on its distribution, phytochemical profile, and medicinal potential.

Keywords: Yellow Ginger Lily; Traditional use; Phytochemistry; Antidiabetic; Zingiberaceae medicinal plants

A review on phytoconstituents and pharmacological potential of *Lepidium sativum*

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Nowadays, herbal plants are gaining popularity as compared to modern medicine as natural products have very few side effects. Ayurveda an ancient Indian medicinal system mentioned various medicinal plants; one of them is *Lepidium sativum* L., known as garden cress and chandrashura in Sanskrit, which is cited in texts like Shodhala nighantu, Bhavaprakasha, Ratnakara, and Adharsha Nigantu. It is said to aid in balancing the Vata and Kapha doshas in Ayurveda. It is used to treat hiccups, diarrhoea, and malaria ancient time. The main objective of this study is to conduct a review on phytoconstituents and pharmacological potential of *L. sativum.* A literature survey has done using internet websites, Google Scholar, Scopus, and PubMed. *L. sativum* is a component of herbal formulation Kasturyadigutica and Chaturbija. Chaturbija include Methika, Kalaji, Yavanika and chandrashura. It is known to have aphrodisiac and galactagogue properties. It is also known to have bronchodilatory, antirheumatic, antimicrobial, antioxidant, and antidiabetic properties. It contains various chemical components like carbohydrates, proteins, vitamins, alkaloids, phenols, terpenoids, and the most abundant secondary metabolites are sinapic acid and 2-phenyl ethyl glucosinolate (gluconasturiin, and glucotropaeolin). Literature studies reveal that seed endosperm of the plant contains phosphorus, iron, zinc, and magnesium while bran contains calcium, and potassium. In conclusion, further clinical study is needed to determine the therapeutic efficiency and safety of pharmacological attribute. Overall, *L. sativum* demonstrates significant promise as a nutraceutical and medicinal resource, requiring further scientific inquiry and application.

Keywords: Chandrashura, Ethanobotany, Ayurveda, Phytochemicals, Pharmacology, Nutraceutical

Study of Research Trends on *Abrus precatorius*

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In the Indian subcontinent, *Abrus precatorius,* also referred to as Ratti, is a medicinal herb having diverse medicinal properties, including antimalarial, antioxidant, hepatoprotective, antibacterial, and anticancer. The aims of this study are to bibliometrically analyze the global, trends, patterns, and relevant research on *A precatorius.* The key word "*Abrus precatorius*" was used to collect data for the period 2000–2026 from the Scopus database (accessed on February 18, 2026). The Bibliometrix software was used to analyze the dataset using the Biblioshiny interface. The dataset (2000–2026) shows a collaborative field with 629 articles from 2,230 authors and 394 sources. The top 50 countries, organizations, sources, and writers were mapped for collaborative networks, with India topping with 242 articles. There were only 34 single-author journals and an average 4.31 co-authors per paper, output shows a moderate degree of international collaboration (13.99%) and a fall (−4.14% annual growth rate). The field shows topic variety with 1,817 keywords and 4,795 references. An average of 21.66 citations per paper and a mean age of 10.7 years reflect a mature research area. Authorship follows Lotka's Law, and journal distribution aligns with Bradford's Law. The findings revealed that research on *Abrus precatorius* needs to be focused on more due to decline in the research trend. These patterns highlight a structured yet uneven distribution of scientific output, reflecting the maturity and stability of the field.

An integrated review of ethnomedicinal uses, phytochemistry profile, and pharmacological activities of *Prinsepia utilis* Royle

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Prinsepia utilis Royle is a deciduous shrub of the Rosaceae family, primarily found in the Himalayan region at elevations ranging from 1000 to 3000 meters above the sea level. It is also known as Bhekal or Himalayan cherry. It has long been used in traditional Indian and Chinese medicine to treat conditions, including skin disorders, rheumatic pain, inflammation, and wound healing. The present study aims to critically review the existing literature on *P. utilis* from multiple scientific databases, conduct a systematic analysis of its phytochemical composition, and assess its pharmacological properties. A systematic review was performed in accordance with PRISMA guidelines. Relevant literature was collected from databases such as PubMed, Google Scholar, Scopus, Web of Science, and Research gate. Phytochemical investigations of plants have revealed 131 different compounds, including terpenoids, flavonoids, alkaloids, cyanogenic glycosides, fatty acids, and various other chemical classes. Many studies have shown that extracts, fractions, and isolated compounds from *P. utilis* display biological activities, such as antibacterial, α-glucosidase inhibitory, lipase inhibitory, and cytotoxic effects. Furthermore, *in vivo* investigations have revealed anti-inflammatory, anti-benign prostatic hyperplasia, osteoprotective, and hypoglycemic activities, supporting its traditional applications. Overall, *Prinsepia utilis* Royle shows strong therapeutic potential supported by traditional use and scientific evidence; however, further clinical and toxicity studies are needed to confirm its safety, efficacy, and future drug development potential.

Static Lines in a Shifting Landscape: Assessing Climate-Driven Threats to Protected Area Adequacy in the Indian Himalayan Region

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The Indian Himalayan Region (IHR), spanning 12 states and affecting 50 million people, it's home to one-tenth of the world's higher-altitude species and half of India's native flora - among 34 global biodiversity hotspots. Documented temperature increases of 1.1-2.5°C have already triggered upward species migration, imposing ecological stress that existing conservation frameworks were never designed to address. Comparative secondary analysis of six authoritative sources: ISFR 2023, MoEFCC Annual Report 2023-24, NITI Aayog IHR Report 2018-19, IPBES 2018, CAG Wildlife Audit 2022, and Tewari et al. 2017. Three structural mismatches emerge. First, India's 998 PAs cover merely 5.28% of geographical area while warming concentrates ecological stress precisely within the most forest-dense altitudinal bands, rendering coverage spatially and altitudinally misaligned. Second, Uttarakhand's net forest decline of 22.98 km² (2021-2023) confirms degradation is already outpacing protection. Third, CAG audit (2022) revealed climate change absent from all sampled PA Management Plans, staff shortages at 41-52%, and Human-Wildlife Conflict escalating 73% - exposing not incidental failure but systemic governance collapse. India's PA framework remains anchored to pre-climate-change assumptions. Mandatory climate vulnerability integration in Management Plans, dynamic boundary revision, and altitudinal corridor development are urgent imperatives.

A Comprehensive Review on Phytochemistry, Ethnobotany and Pharmacology of *Ajuga bracteosa*: An Endangered Himalayan Medicinal Herb

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For thousands of years, people have relied on medicinal plants to cure diseases and to stay healthy. About 25% of modern medicines are derived directly or indirectly from plant sources. India is abundant with a remarkable diversity of medicinal plants which form the basis of traditional health care systems. One such valuable medicinal herb is *Ajuga bracteosa* Wall. Ex. Benth., an endangered medicinal herb from the Himalayas. This plant belongs to the family Lamiaceae, is a perennial herb commonly referred to as the Kauri booti (Kori booti) also known by various vernacular names such as Nilkanthi, Jan-i-adam, Ratpatha. that grows across the subtropical and temperate zones of Western Himalayas, at the altitudes of 1300-2400 meters above sea level. It also mentioned in the traditional medicinal systems such as Ayurveda and Chinese Medicine Systems. It is known to have anti-inflammatory, antimalarial, antidiabetic, analgesic, antioxidant, hepatoprotective, and anti-arthritic properties. The main objective of this study is to unveil the potential and to review all available scientific information about *A. bracteosa*. The study revealed that it is a highly valuable medicinal plant with a wide range of therapeutic properties. Neo-clerodane diterpenoids (ajugarin, lupulin A, and clerodinin A), diterpenoids (ajugapitin and clerodin dihydroAjugapitin), phytoecdysteroids (cyasterone and 20-hydroxyecdysone) iridoids (8-O-acetylharpagide, reptoside) are the most common bioactive constituents of the plant. Therefore, *A. bracteosa* has a great potential as a valuable medicinal resource that requires further scientific investigation, and sustainable utilization to preserve it for future generations.

Keywords: Antioxidant, Kori booti, Ethnobotany, Phytochemicals, Pharmacology

Climate Change Impact on Shimla and Solan

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Climate change has emerged as a serious environmental challenge affecting the Himalayan districts of Shimla and Solan in Himachal Pradesh. This research examines the impact of changing climatic conditions on temperature, rainfall patterns, agriculture, tourism, biodiversity, and disaster vulnerability in these regions. Rising temperatures, irregular precipitation, reduced snowfall, and increasing incidents of landslides, cloudbursts, and flash floods have intensified environmental and socioeconomic risks. In Shimla, changing climate patterns have weakened slope stability, increased water scarcity, and created pressure on tourism infrastructure and forest resources. In Solan, agriculture and horticulture are adversely affected due to shortened winters, declining chill hours, and fluctuating rainfall, resulting in reduced productivity of temperate fruits and changes in crop patterns. The study can be classified as descriptive, analytical, environmental, and mainly qualitative research because it explains and analyzes the causes and consequences of climate change using observations, reports, and literature review. Human activities such as rapid urbanization, deforestation, road expansion, and uncontrolled tourism have further aggravated environmental stress in both districts. The research concludes that climate change poses serious threats to the fragile Himalayan ecosystem and local livelihoods. Effective adaptation and mitigation strategies such as afforestation, scientific urban planning, climate-resilient agriculture, sustainable tourism, and disaster management are essential for reducing environmental risks and ensuring long-term sustainability in Shimla and Solan.

Extraction of Cellulose Nanofibers from invasive weed *Lantana camara* for Biodegradable PVA (Polyvinyl alcohol) Nanocomposites

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Climate change is affecting ecosystem around the globe by altering temperatures, habitats, reducing biodiversity, and encouraging the spread of invasive species. The invasive weed *Lantana camara* is spreading more aggressively under these climate changes, posing a serious threat to native biodiversity and ecosystem stability, necessitating sustainable strategies for its utilization and management. In the present study, cellulose nanofibers (CNFs) were successfully extracted from *Lantana camara* stem biomass through an integrated chemomechanical approach. The extracted CNFs were subsequently incorporated into polyvinyl alcohol (PVA) to fabricate biodegradable nanocomposite films. FTIR analysis confirmed the effective removal of lignin and hemicellulose during processing, while XRD analysis revealed an increase in crystallinity from 38.6% in raw fibres to 54.0% in CNFs, indicating enrichment of the crystalline cellulose fraction. HR-TEM analysis demonstrated the formation of well-dispersed web-like nanofibrils with an average diameter of approximately 14.5 nm. The incorporation of CNFs into the PVA matrix significantly influenced the optical and biodegradation properties of the films. Films containing up to 3 wt% CNFs retained high transparency in the

visible region, whereas higher CNF loading improved UV-shielding performance. Soil burial studies demonstrated the biodegradable nature of the developed films, although increasing CNF concentration reduced the degradation rate due to enhanced structural stability. The findings highlight the potential of invasive weed biomass as a renewable feedstock for the development of sustainable nanomaterials and biodegradable packaging films supporting biodiversity conservation, biomass valorization, and eco-friendly alternatives to petroleum-based plastics.

In vitro approach for mass propagation of *Melissa officinalis*

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Melissa officinalis is a perennial bushy medicinal herb belonging to family Lamiaceae. The plant is native to central Asia and Europe. It is widely known as lemon balm due to its mild lemon scent. The plant exhibits multiple leafy branches and grows upto the height of 30-125 cm. Studies suggests the plant is rich in phytoconstituents such as Rosmarinic acid, Flavonoids, essential oils such as citral, citronellal, limonene, geraniol, and beta–caryophyllene, phenolics, and tannins. Owing to the presence of these compounds, plants exhibit various therapeutic and pharmacological activities, such as anxiolytic, antioxidant, anticancer, anti-inflammatory, sedative, carminative, antimicrobial, and neuroprotective. Several studies revealed that plant help to improve cognitive function, sleep quality, reduce mild anxiety, and relieve conditions like hypertension and Alzheimer's disease. Traditionally, the plant has been used in preparation of Herbal Tea and as a medicinal and functional food since ages. *M. officinalis* highlights very high potential in pharma and cosmetics. Due to low yield of essential oils, low seed viability and continuous natural exploitation has increased need for sustainable strategies. Thus, *In vitro* techniques can be considered as a promising approach to improve its production, phytochemical yield and exploit best of it while conserving it for future.

Keywords: Lemon balm; pharmacological activity; phytoconstituent; Melissa; essential oil

In vitro studies and phytochemical analysis of *Origanum majorana* (sweet marjoram)

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Origanum majorana L. is an important medicinal and aromatic herb which is a member of Lamiaceae family. It is endemic to Cyprus, Turkey, and the Mediterranean region, and is cultivated globally for its culinary, therapeutic benefits and essential oil. This plant is also known as sweet marjoram, pot marjoram and maruvaka. The leaves are traditionally used in the form of decoction and powder to treat allergies, flu, hypertension, respiratory infections, diabetes, and menstrual pain. Therapeutic potential of *Origanum majorana* is due to the presence of major bioactive compounds like linalool, terpenen-4-ol, carvacrol, α-terpinene, γ-terpinene, cis-sabinene hydrate, p-cymene, bornyl acetate and β-caryophyllene. These phytoconstituents exhibit pharmacological properties such as anti-cancer, anti-inflammatory, anti-oxidant, anti-microbial, cardioprotective, hepatoprotective activities and are used to manage hormonal levels during the menstrual cycle and polycystic ovarian syndrome (PCOS). Essential oil extracted from the herb is used in aromatherapy and applied externally to sprains and bruises. *Origanum majorana* is exploited substantially due to its vast demand in food, cosmetic, beverage, perfume and pharmaceutical industries. The plant thrives in well- drained sandy and loamy soil, its growth is affected in cold weather and during the rainy season, which makes it difficult for the plant to grow around the year. Therefore, an attempt has been made to counteract this problem by utilizing *in vitro* cultivation methods. These approaches can help meet the growing industrial demand for raw plant materials and bioactive compounds used in the pharmaceutical, cosmetic, food, beverage, and perfumery industries.

Keywords: In vitro cultivation; Origanum majorana; pharmacology; phytoconstituents; ethnobotany

Ethnobotanical exploration of wild edible fruits and berries in Kangra District, Himachal Pradesh

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The presence study explores the diversity and therapeutic significance of fruit bearing plant species. Located in the foothill region of Western Himalayas, the area is characterized by varied topography and favorable climatic conditions that support rich vegetation, including numerous wild and cultivated fruits and berries with recognized medicinal value. The study involved systematic field exploration for locating, observing, and documenting wild edible fruits and berries of medicinal importance. Scientific publications, and research articles were consulted to compile detailed information regarding botanical description, phytochemical constituents, nutritional composition, and pharmacological activities associated with the documented species. Many of the fruits and berries from this region are rich source of bioactive compounds such as flavonoids, phenolics acids, tannins, vitamins and other secondary metabolites. These constituents are widely reported for their antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties. In addition to their therapeutic significance, these fruits contribute to nutritional security and possess considerable potential for nutraceutical applications. The findings highlight the medicinal richness of wild edible fruit diversity in Jaisinghpur tehsil and emphasize the importance of conserving these valuable plant resources. The compiled information may serve as a scientific foundation for future phytochemical analysis, pharmacological validation, and sustainable utilization of wild edible fruit species in these regions.

Keywords: Western Himalayas; wild edible fruits; nutraceuticals; biodiversity conservation

Phytochemical analysis and *in vitro* propagation of *Thymus vulgaris*

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Medicinal plants knowingly or unknowingly aided the human health since ages. The plants served as primary source of treatment for a wide range of ailments. *Thymus vulgaris*, commonly known as thyme belonging to family Lamiaceae is widely recognized for its diverse bioactive phytochemicals which possess potent anti-oxidant properties, anti-microbial and therapeutic properties. The present study was undertaken to evaluate *Thymus vulgaris* through phytochemical, biochemical, anatomical, and spectroscopic approaches with the aim of establishing a detailed scientific profile of this valuable medicinal plant. Preliminary qualitative phytochemical screening was carried out on different plant parts of *Thymus vulgaris* to detect the majorly present secondary metabolites including alkaloids, flavonoids, saponins, terpenoids, phenol, and glycosides. Essential oil extracted from aerial parts via clever apparatus was subjected to GC-MS analysis which enabled identification and quantification of major & minor volatile constituents. Even after having such potential, growing threat of overexploitation and habitat degradation faced by *Thymus vulgaris.* Therefore, *in vitro* conservation approach was exploited using nodal and shoot tip explants cultured on MS media. The findings of the present study provide an alternative for the conservation of this important medicinal plant and its phytochemical screening, therefore contributing valuable data for its quality control, germplasm preservation, and potential pharmaceutical exploitation.

A Survey on Disease Incidence in Apple Grown in Lower Regions of Himachal Pradesh

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Apple (*Malus domestica* Borkh.) is an economically important temperate fruit crop that contributes significantly to the horticulture economy of Himachal Pradesh. However, apple cultivation in lower hill regions is increasingly affected by the diseases that adversely impact plant health and productivity. The present study was conducted to assess the prevalence and severity of diseases in apple grown in the lower regions of Himachal Pradesh. Field surveys were carried out in five apple orchards located in lower hill regions, including parts of Kangra and Bilaspur districts. A total of 50 apple plants were surveyed for visible disease symptoms. Disease identification was performed based on characteristic field symptoms, while disease severity was assessed using a 0-4 scoring scale. Disease frequency and Percent Disease Index (PDI) were calculated to evaluate the disease distribution and intensity. The survey revealed the occurrence of Alternaria blotch and Marssonina blotch as the major diseases in the surveyed orchards. Alternaria blotch was observed as the predominant disease with comparatively higher disease frequency and severity in most orchards. High severity and elevated PDI values were recorded in orchards, indicating high disease intensity and favorable conditions like high humidity for disease development. Variation in disease intensity and PDI was observed among orchards, possibly due to differences in orchard management practices and microclimatic conditions favorable for fungal disease development. The study provides preliminary region-specific information on apple disease prevalence in lower Himachal Pradesh and highlights the importance of regular monitoring and disease management practices for sustainable apple cultivation.

Climate Change Adaptation through Biodiversity Conservation and Sustainable Resource Use in Himachal Pradesh

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Himachal Pradesh, situated in the north-western Himalaya, is among India's most ecologically diverse and environmentally sensitive states. Its forests, alpine pastures, wetlands, and river systems support a wide range of plant and animal species while sustaining agriculture, tourism, and rural livelihoods. In recent decades, the state has experienced noticeable changes in climate, including increasing temperatures, irregular precipitation, reduced snowfall, glacier retreat, and a rise in extreme events such as flash floods, cloudbursts, and landslides. These changes are altering ecosystem processes and placing growing pressure on biodiversity and the communities that depend upon it. Biodiversity conservation and the sustainable use of biological resources are central to climate change adaptation in Himachal Pradesh. Intact ecosystems help regulate water flow, stabilize slopes, store carbon, and provide food, fodder, fuelwood, and medicinal plants. Conserving native forests, restoring degraded habitats, and protecting ecologically important areas enhance the resilience of both natural systems and local communities. At the same time, sustainable practices such as agroforestry, organic farming, community-based management of medicinal plants, and nature-based tourism can generate income while reducing stress on fragile ecosystems. Adaptation efforts in Himachal Pradesh increasingly emphasize watershed management, climate-resilient agriculture, disaster preparedness, and participatory conservation through local institutions such as Biodiversity Management Committees. Combining scientific knowledge with traditional ecological practices offers practical pathways for addressing climate risks. A coordinated approach that links biodiversity conservation with sustainable development is essential to safeguard ecological stability and strengthen the adaptive capacity of mountain communities in Himachal Pradesh.

Land Use Land Cover(LULC) Analysis of Solan District, Himachal Pradesh

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The Land Use Land Cover (LULC) dynamics of the Solan district in Himachal Pradesh are assessed in this study between 2016 and 2025**.** Anthropogenic activities are rapidly changing terrestrial surfaces, which makes ongoing monitoring necessary for sustainable development. In order to categories the area into six different classes—Water, Urban, Dense Forest, Open Forest, Agriculture, and Barren Land—multi-temporal satellite imagery was processed using Google Earth Engine's (GEE) computational efficiency. The analysis shows a notable increase in urban areas (+0.07 km) and open forests (+2.50 km). These improvements are contrasted with a significant decrease in barren areas (-0.50 km) and agricultural land (-2.00 km). The main causes of these changes are growing urbanization and changing demographics, as urban areas grew considerably while agricultural land shrank. By integrating rainfall data from the last five years, the environmental context is further clarified. In comparison to a low of almost 0mm in 2023, recorded rainfall showed notable variability, peaking at about 38mm in 2024. This study demonstrates that GEE offers a quick and precise framework for environmental monitoring in mountainous areas. These results are crucial for Solan's sustainable land management and well-informed decision-making.

Keywords: LULC, Remote Sensing, GIS, Solan District, Land Use Change, NDVI

Ecological niche modeling assessment of the Climate Change Threats to the Endemic Shrub *Strobilanthes kunthianus* in the Southern Western Ghats, India

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Strobilanthes kunthianus, also known as Neelakurinji, is a rare mass-flowering shrub endemic to high-elevation sky-islands of India's Southern Western Ghats. The species is facing severe survival threats due to anthropogenically driven climate change. The research uses the Maximum Entropy (MaxEnt) modeling algorithm to predict the species' probable habitat and range-shifts under median (RCP 4.5) and extreme (RCP 8.5) emission scenarios for 2030, 2050, and 2080. MaxEnt robust modeling techniques revealed precipitation during the driest month, isothermality, and annual mean temperature as the key environmental factors influencing the species distribution. The shrub currently occupies a relatively restricted fundamental niche, which is ~1.4% of the Western Ghats, and is mostly found in the montane shola habitats of the Nilgiri, Annamalai, and Palani Hills. Alarmingly, future estimates indicate a significant shrinkage in its habitat range. By 2080, the median emission scenario forecasts that 93% of its habitat will be lost, while the extreme scenario predicts near-total habitat loss, which may lead to extinction risk. The susceptibility of *S. kunthianus* is exacerbated by the "Summit Trap" phenomenon; it currently occupies upper hill slopes but lacks the altitude required for upslope migration. Coupled with restricted seed dispersion and highly climate-sensitive flowering cycles, the species may slip into the endangered category. To avert *S. kunthianus* contraction, the research advocates effective adaptation strategies such as judicious habitat zonation, tailored land-use management, development of protected areas corridors, and strong legislative interventions.

Snow Cover and Snowline Altitude Analysis of Miyar Glacier (2013–2024) Using Google Earth Engine

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Himalayan glaciers are among the most sensitive indicators of climate change, and their monitoring is critical for understanding regional hydrology and water resource management. This study presents a comprehensive analysis of snow cover dynamics and Snowline Altitude (SLA) for Miyar Glacier, located in the Lahaul and Spiti district of Himachal Pradesh (Western Himalayas), over the period 2013–2024. Using Google Earth Engine (GEE), Landsat 8 OLI/TIRS imagery, SRTM Digital Elevation Model (DEM), and ERA5-Land Monthly Aggregated reanalysis data, annual NDSI-based snow cover maps were generated and snowline altitudes were extracted. Annual snow cover ranged from 18.4 km² (2020) to 31.7 km² (2022), with a mean of 24.6 ± 3.9 km². Annual SLA varied between 5,098 m (2013) and 5,347 m (2018), yielding a net rise of 249 m over the study period. Pearson correlation between mean annual temperature and SLA yielded r = 0.81 (p = 0.002), confirming a statistically significant positive relationship. The multi-year mean SLA of 5,224 m agrees within ±35 m of published ELA estimates for Chhota Shigri Glacier, a comparable benchmark in the Western Himalayas. The results demonstrate that cloud-based remote sensing provides a scalable, reproducible methodology for high-altitude glacier monitoring without costly field campaigns.

Keywords: Miyar Glacier, Google Earth Engine, NDSI, Snowline Altitude, Landsat 8, ERA5-Land, Himalayan glaciers, remote sensing, climate change, snow cover monitoring.

Snow Cover

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Snow cover plays a crucial role in regulating hydrological processes, climate dynamics, and water resource availability in mountainous regions. The present study focuses on analyzing the spatio-temporal variability of snow cover in the Pir Panjal Range of the Western Himalayas over a period of 25 years (2000–2025). Using Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data, the research aims to quantify annual snow cover extent and examine elevation-dependent trends, particularly shifts in snowline altitude. Snow cover was predominantly observed between 3000–5000m.The study utilizes remote sensing and geospatial techniques through Google Earth Engine (GEE) to process large datasets efficiently. Snow cover area was extracted annually and analyzed across different elevation bands to identify patterns and trends. The results indicate that snow cover distribution is strongly influenced by elevation, with the majority of snow accumulation occurring between 3000 m and 5000 m. Peak snow cover density was observed around 4000–4500 m, corresponding to mid-to-high mountain zones.Temporal analysis reveals variability in snow cover extent, likely influenced by climatic factors such as temperature rise and precipitation changes. The study also suggests a gradual upward shift in snowline altitude, indicating the impact of climate change in the region. These findings are significant for understanding water resource management, glacier dynamics, and climate adaptation strategies in the Himalayan region. Overall, this research highlights the importance of remote sensing in monitoring cryospheric changes and provides a baseline for future studies related to snow cover dynamics and environmental sustainability.

Chemical Space Exploration of Marine Natural Products and their Chemoinformatic Analysis

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The utilization of natural products goes back to the dawn of humanity where early humans relied on living organisms around them as their principal source of bioactive compounds. Traditionally, living organisms were considered the primary source of medicinal compounds. Advances in the field of organic chemistry and analytical sciences have revealed that biological activities arise from specific bioactive organic molecules known as natural products, which are synthesized by living organisms and perform essentials roles in defense, metabolism, and cellular interactions. Although natural products derived from terrestrial organisms are extensively studied, considerably less attention has been given to natural products derived from marine organisms. In this study, a comprehensive repository of natural products was utilized to identify marine derived compounds using marine species data. The dataset was classified according to chemical and biosynthetic origins and further analyzed using physicochemical descriptors, drug-likeness evaluation, scaffold diversity analysis, bioactivity mapping, protein target classification, and chemical space projection. The analysis revealed that although a few chemical classes were dominant, the dataset remained broadly distributed across multiple categories, indicating considerable chemical diversity. Several compounds satisfied drug-likeness criteria and exhibited favorable Quantitative Estimate of Drug-likeness (QED) scores. Scaffold analysis revealed high structural diversity, as indicated by an elevated scaled Shannon entropy score. Binding and catalytic protein classes were dominant among active targets. Chemical-space analysis further showed that marine natural products are structurally diverse and physicochemically distinct, while active compounds occupied a comparatively restricted region. The present study demonstrates that chemoinformatics offer a robust computational framework for exploring and prioritizing marine-derived compounds for drug discovery process.

Antioxidant properties of Plant Extracts: A meta-analysis for best extraction conditions

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It has long been known that medicinal plants are significant sources of bioactive substances with therapeutic potential. Global interest in plant-derived antioxidants and antibacterial agents has increased recently due to rising antimicrobial resistance and illnesses linked to oxidative stress. This review and meta-analysis assess the antioxidant and antibacterial properties of medicinal plants reported in recent scientific literature. In accordance with PRISMA principles, studies published in peer reviewed journals were systematically retrieved from databases such as PubMed, Scopus, and Web of Science. While antibacterial effectiveness was assessed using agar well diffusion, disc diffusion, minimum inhibitory concentration (MIC), and minimum bactericidal concentration (MBC) methods, major antioxidant assays, such as DPPH, FRAP, and total phenolic content analyses, were also considered. The findings suggest that medicinal plants with high levels of phenolics, flavonoids, tannins, alkaloids, and terpenoids have important antibacterial and free-radical scavenging properties. Strong biological activity has been observed across plant groups such as Lamiaceae, Asteraceae, Fabaceae, and Rutaceae. Compared with aqueous extracts, methanolic and ethanolic extracts typically exhibit greater antioxidant and antibacterial efficacy. A meta-analysis revealed a favourable association between antioxidant potential and total phenolic content, indicating that phenolic chemicals are important for therapeutic efficacy. Considering the observations of the present study, it is concluded that medicinal herbs offer promising natural alternatives to synthetic antioxidants and antibiotics.

Keywords: Medicinal plants, Antioxidant, Antibacterial, and DPPH Assa

Climate-Resilient Rice for Heavy Metal–Contaminated Agroecosystems: Integrated Genomic and Phylogenetic Dissection of Cadmium and Lead Stress Tolerance

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Heavy metal contamination of agricultural soils is an escalating threat to crop productivity, food safety, and sustainable agriculture under changing climate conditions. Rice (Oryza sativa L.), as a major staple crop, is particularly vulnerable to cadmium and lead accumulation because of its flooded cultivation system and high uptake potential. This study proposes an integrated approach to uncover the molecular basis of heavy metal stress resilience in rice by combining meta-QTL analysis, candidate gene mining, haplotype-trait association, phylogenetic reconstruction, and functional marker development. The research will identify consensus genomic hotspots linked to Cd and Pb tolerance, prioritize genes involved in transport, chelation, sequestration, antioxidant defense, and signaling, and assess allelic variation across diverse rice germplasm. Promoter and expression analyses will help characterize stress-responsive regulatory elements, while phylogenetic comparisons will reveal evolutionary signatures associated with metal adaptation. The expected outcome is a set of validated metal-specific candidate genes and diagnostic markers that can support climate-smart breeding of safer and more resilient rice cultivars for contaminated environments.

Keywords: Rice, cadmium, lead, heavy metal stress, meta-QTL, phylogenetics, climate resilience

Integration of transcriptome and metabolome profiling reveals dedifferentiation, redifferentiation and secondary metabolite dynamics in *Ferula assa-foetida L.*

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Developing a reliable plant regeneration system is essential for the successful application of genetic engineering in plants. *Ferula assa-foetida*, an economically valuable spice and medicinal species, demands an optimized regeneration protocol to support its large-scale propagation, conservation, and genetic improvement. We have standardized somatic embryogenesis protocol of *F. assa-foetida* by confirming different stages i.e., globular, heart, torpedo, and cotyledonary stages. Novel data mining approaches using artificial neural networks (ANNs) and machine Learning (ML) algorithms can facilitate modeling and optimization of *in vitro* organogenesis, thereby reducing large experimental designing. Furthermore, to unravel the molecular mechanism that regulates cell fate, totipotency and secondary metabolite production at six developmental stages (leaf explant, callus, embryogenic callus, *in vitro* shoot, *in vitro* root, acclimatized root) were studied. Thus, to gain deeper insight into *in vitro* organogenesis, metabolic profiling was performed and integrated with transcriptomic data. Non-targeted qualitative profiling using LC-MS, GC-MS and GC-FID analysis revealed elevated primary and secondary metabolites in the *in vitro* root and acclimatized root compared to those in the mother plant. Furthermore, GC-FID analysis revealed fatty acid profile associated with organogenesis. Moreover, differential gene expression and functional analysis showed secondary metabolism related genes were downregulated during differentiation and upregulated at the onset of redifferentiation. Expression profiles of morphogenesis and secondary metabolism-related genes were validated by real time PCR during different stages. Present study offer novel understanding of the molecular basis governing regeneration in *F. assa-foetida* and highlight their potential application in improving the production of plant secondary metabolites.

Exploring Indigenous Rhizobacteria for Climate Adaptation and Sustainable Agriculture in Himalayan region

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The Himalayan ecosystem inhabits a rich diversity of microorganisms that contribute significantly for biodiversity conservation and agriculture resilience under extreme environmental conditions. The given research delivers an indigenous cold-adapted bacteria from Himalayan rhizosphere. The isolate exhibits a variety of plant growth promoting traits including phosphate solubilization, indole-acetic production, and siderophore production under cold climate conditions. The efficiency of given bacterium is assessed *via* seed priming assay with Fenugreek (*Trigonella foenum-graecum*) crop under cold-stress. The notable enhancement in seed germination index and plant physiological traits shows the potential of given isolate in contributing for climate resilient agriculture in Himalayan region. In addition to Plant growth promotion, a substantial antagonistic potential against fungal phytopathogens indicate the bacterium as a remarkable environment-safe biocontrol agent. Further, the genome analysis of given microbe revealed diverse set of genes involved in imparting cold adaptation and stress response regulation. Therefore, the study shows ecological relevance of conserving Himalayan indigenous phytobiome for contributing towards climate-resilient agriculture. The prospection of native microbial community as biofertilizers and biocontrol agents can improve sustainable agricultural practices with reduction in chemical hazards from agriculture system. The given research findings suggest integration of potential microbes into conservation-oriented farming regimes for improving soil health and crop productivity in Himalayan ecosystem.

Integrated *in vitro* culture and genetic transformation strategies for metabolite enhancement and bioconservation in tea

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Tea (*Camellia sinensis*) is a globally important beverage crop valued for its rich antioxidant and secondary metabolite composition. However, climate change–induced environmental stresses, narrow genetic diversity, and limitations in conventional breeding threaten sustainable tea production and long-term germplasm conservation. The present study integrated in vitro culture optimization with somatic embryogenesis and Agrobacterium-mediated transformation to establish a sustainable platform for metabolite enhancement, bioresource conservation, and climate-resilient tea improvement in the elite cultivar Kangra Asha. Callus cultures were established on Murashige and Skoog (MS) medium supplemented with 1000 mg/L casein hydrolysate, 2.5 mg/L 6-benzyladenine (BA), 0.1 mg/L naphthaleneacetic acid (NAA), and 500 mg/L L-glutamine using different carbon sources, including sucrose, glucose, maltose, fructose, sorbitol, and their combinations. Carbon source significantly influenced callus growth, biochemical responses, antioxidant activity, and elemental composition. Fructose-containing media enhanced total phenolic accumulation, with maximum phenolic content observed in the maltose–glucose combination, whereas flavonoid accumulation was highest in sucrose-grown callus and in the glucose–fructose combination among mixed treatments. Maltose-supported cultures exhibited the highest DPPH radical scavenging activity, while sorbitol enhanced reducing power and total antioxidant capacity, indicating improved stress-responsive metabolic potential. In parallel, an efficient somatic embryogenesis and transformation system was standardized using de-embryonated cotyledon explants. Embryogenic cultures were transformed using *Agrobacterium tumefaciens* strain *EHA105* carrying pCAMBIA1304, and putative transformants were confirmed through PCR and GUS analyses. The optimized protocol provides a reliable and sustainable strategy for conservation of elite tea germplasm, enhanced production of protective bioactive metabolites, and development of climate-resilient tea cultivars for future adaptation under changing environmental conditions.

Climate Change and Rainfall Extremes: A Spatio-Temporal Analysis of Himachal Pradesh

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Climate change has emerged as a critical driver of hydro-meteorological variability in mountainous regions, particularly in the Himalayan state of Himachal Pradesh. Recent decades have witnessed increasing irregularities in rainfall patterns, with a notable rise in the frequency and intensity of extreme rainfall events, often resulting in floods and landslides resulting in infrastructure damage and loss of life. The present study aims to analyze the spatio-temporal variability of rainfall. It also tries to identify trends in extreme rainfall events to understand their linkage with changing climatic conditions. The primary objective is to evaluate changes in rainfall behaviour and detect increasing extremes as indicators of climate change. The study utilizes high-resolution India Meteorological Department (IMD) gridded rainfall data for the period 1990–2025. Trend analysis and moving averages are employed to examine temporal changes, while extreme rainfall indices e.g., heavy and very heavy rainfall days are computed to assess intensity patterns. Following this, spatial analysis is conducted using GIS tools to map rainfall distribution, variability, and emerging hotspots of meteorological extremes across Himachal Pradesh. The research seeks to provide insights into regional climate dynamics and support disaster risk reduction planning. By integrating statistical and geospatial approaches, the study contributes to understanding how climate change is influencing rainfall extremes in fragile mountain ecosystems.

Keywords: Climate Change, rainfall extremes, hydro-meteorological variability, mountain ecosystem.

An Analytical Study of Disaster Management and preparedness initiaves in Shimla

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Shimla, situated in the fragile Himalayan ecosystem, has become increasingly vulnerable to disasters such as landslides, floods, fire incidents, and infrastructure collapse. Rapid urbanization, climate variability, unplanned construction, and inadequate drainage systems have significantly increased disaster risks in the region. The present study examines the nature and causes of disasters in Shimla and evaluates the effectiveness of disaster management practices adopted by the District Disaster Management Authority (DDMA). The study is based on both primary and secondary data. Primary data were collected through a structured questionnaire administered to DDMA officials, while secondary data were obtained from news reports, government records, and recent disaster-related case studies in Shimla. The research focuses on disaster preparedness, response mechanisms, infrastructure vulnerability, and rehabilitation measures. The findings indicate that landslides, floods, and fire incidents are among the most frequent disasters affecting Shimla. The study further reveals that geo-climatic conditions, increasing urbanization, tunnelling and construction activities, and poor drainage infrastructure are the major factors contributing to disaster vulnerability. Although disaster response systems, mock drills, and interdepartmental coordination are functioning effectively, there remains a need to strengthen early warning systems, sustainable urban planning, and community-based disaster preparedness initiatives. The study concludes that an integrated and proactive approach to disaster risk reduction, supported by environmental sustainability and coordinated governance, is essential for enhancing resilience and minimizing disaster impacts in Shimla.

Rainfall, Active Tectonics, and Human Interference as Major Drivers of Landslides in the Jawalamukhi Region, NW Himalaya

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Heavy rainfall events from July to September 2025 triggered numerous landslides in the northern part of the Jawalamukhi region, particularly affecting villages such as Majheen and Amred. The study area lies within an active tectonic regime on the hanging wall of the Jawalamukhi Thrust (JT), a major tectonic structure of the northwestern Himalaya. Continuous tectonic activity along this thrust has caused intense deformation, fracturing, and weakening of slope-forming materials, significantly increasing the susceptibility of the terrain to slope instability and mass movement. In this area the bedrock generally dips towards the north-northeast and contains highly jointed planes, while the overlying colluvial material follows the natural slope gradient. Continuous rainfall during July to September 2025 caused progressive saturation of the entire slope region, while the intense rainfall event of 25 September 2025 acted as the immediate trigger for slope failure. The tectonically fractured and highly jointed sandstone facilitated rapid percolation of water into deeper layers, resulting in elevated pore-water pressure within the slope mass. This led to large-scale downslope movement of saturated debris under gravitational influence. Field investigations revealed tension cracks, tilting and uprooting of trees, displacement of rock fragments, ground subsidence, and severe damage to houses and infrastructure. The study recommends immediate implementation of scientifically designed slope drainage systems to prevent infiltration of surface runoff into vulnerable slope materials. In addition, bioengineering measures such as plantation of high water-absorbing vegetation is suggested to reduce soil saturation, improve root reinforcement, and enhance long-term slope stability in the tectonically active Jawalamukhi region.

Integrated Remote Sensing Approaches for Forest Fire Risk Mapping in Subtropical Himalayan Pine Forests

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Forest fire is a serious environmental problem in the subtropical Himalayan Pine forests of Himachal Pradesh and Uttarakhand. These regions are highly vulnerable due to summer climate conditions, the dominance of Chir pine (Pinus roxburghii), steep slopes, and increasing human activities such as fuelwood collection. In recent years, forest fires have increased in both frequency and intensity, leading to significant damage to biodiversity, soil fertility, and overall ecosystem stability. Forest fires also contribute to loss of valuable natural resources, making them a major concern for environmental management. This study aims to develop an integrated and simple approach to map forest fire risk using remote sensing and GEOGRAPHICAL INFORMATION SYSTEM (GIS) Techniques. The main objectives are to analyze the key factors responsible for forest fire occurrence and to generate a reliable forest fire risk map using geospatial data. Satellite data is processed using Google Earth Engine, which helps in efficient handling and analysis of large datasets over time. The study considers important factors such as vegetation condition, slope, aspect, wind speed and land use and land cover (LULC). Vegetation health is analyzed using the Normalized Difference Vegetation Index (NDVI). All the factors are combined using a multi- criteria method such as the Analytical Hierarchy Process (AHP) or weighted overlay. The final output is a forest fire risk map dividing the area into low, Moderate, High, and very high-risk zones, Supporting effective fire management and planning.

Keywords: Forest Fire Vulnerability, Google Earth Engine, Remote Sensing, GIS, NDVI, Chir Pine Forests, AHP, LULC.

Assessing Urban Heat Island (UHI) Dynamics in Shimla District (2021–2024): A Cloud-Computing Approach Using Landsat 8 and Google Earth Engine

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The Urban Heat Island (UHI) phenomenon poses an increasing threat to ecologically sensitive mountain cities. This study quantifies UHI intensity and hotspot dynamics in Shimla District, Himachal Pradesh, India, across four consecutive summer seasons (2021–2024) using Landsat 8 satellite imagery processed within the Google Earth Engine (GEE) cloud-computing platform. Land Surface Temperature (LST) was derived from Band 10 of the Landsat 8 Collection 2 Tier 1 Level 2 product. Unlike a fixed-threshold approach, hotspot classification employed both an absolute anomaly criterion (≥2.5°C above the district mean) and a spatially adaptive percentile-based criterion (top-decile LST pixels), with high inter-criterion spatial agreement (Jaccard Index 0.69–0.81). Satellite-derived LST was validated against IMD Jubbarhatti station data, confirming agreement within ±1.5°C after accounting for the physical LST−T offset. NDVI–LST Pearson correlations (~−0.77) and LULC class analysis confirm that deforestation and built-up expansion are structural UHI drivers. The 2024 district-mean LST of 30.33°C is rigorously attributed to a compound heatwave event using IMD bulletins and ERA5 reanalysis. Sub-district mapping identifies Shimla Urban and Rampur tehsils as priority heat-action zones.

Geospatial Modeling of Landslide Susceptibility and Vegetation Trends in Rudraprayag District (2019-2024)

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Landslides are among the most destructive natural hazards in the Himalayan region, with the Rudraprayag district of Uttarakhand being particularly vulnerable due to steep topography, fragile geology, intense monsoon precipitation, and rapid land-use change. This study aims to assess landslide susceptibility in the Rudraprayag district using a geospatial multi-factor approach within a cloud-based computing environment, while also examining vegetation dynamics over the 2019–2024 period. The analysis was performed using Google Earth Engine (GEE), integrating eight conditioning factors: slope and aspect derived from SRTM DEM, rainfall from CHIRPS data, soil moisture inferred from Sentinel-1 SAR backscatter, vegetation condition using NDVI from Sentinel-2 imagery, land use/land cover from ESA World Cover, population density from World Pop, and proximity to river channels. Each factor was reclassified using threshold-based criteria and combined through a weighted overlay method to generate a Landslide Susceptibility Index (LSI). The results indicate that a significant portion of the study area falls under moderate to high susceptibility zones, particularly in regions characterized by slopes exceeding 35°, high rainfall intensity, low vegetation cover, and close proximity to river networks. Temporal NDVI analysis suggests a decline in vegetation greenness between 2019 and 2024, indicating potential degradation of slope-stabilizing vegetation. Areas with higher susceptibility also show increased interaction with populated regions, highlighting the role of anthropogenic pressure in hazard exposure. The study demonstrates the effectiveness of integrating multi-source satellite data within GEE for rapid and scalable landslide susceptibility assessment. The resulting susceptibility map, generated at 30 m resolution, provides a useful tool for land-use planning and disaster risk management in the Himalayan region.

Integrated Geospatial Approach for Landslide Hazard Zonation and Future Risk Assessment in the Kotrupi Region, Himachal Pradesh

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This study examines landscape changes and future risk potential associated with the 2017 Kotrupi landslide along NH-154 in Mandi, Himachal Pradesh, using an integrated geospatial approach. Significant geomorphological changes were observed, including slope failure, vegetation loss and alterations in surface hydrology driven by intense rainfall. A comparative multi-temporal analysis was conducted using datasets from 2016–2018 on the Google Earth Engine platform, alongside historical rainfall and vegetation records to establish baseline stability conditions. NDVI time-series analysis indicated a sharp decline during the 2017 event, while a comparative study of previous years highlighted that the 2017 failure was preceded by cumulative slope weakening. SAR backscatter results further confirmed increased soil moisture conditions before the landslide. To support future disaster mitigation, topographic parameters from DEM data and land-use patterns were integrated into a weighted overlay-based Multi-Criteria Decision Analysis (MCDA). The combination of slope, inverse NDVI, and rainfall factors enabled the generation of a Landslide Hazard Zonation (LHZ) map. The results indicate that approximately 31% of the study area falls within the high hazard category, suggesting a continued risk of landslide reactivation. The study highlights the usefulness of geospatial techniques for landslide assessment and future risk identification. The findings can support early warning systems, disaster management, and infrastructure planning in mountainous regions, with a focus on improving preparedness in the Himalayan region.

Landslide Susceptibility Mapping of Kiratpur Manali Highway (NH-3) using AHP, GEE & GIS

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In the mountainous region, landslides remain one of the most damaging natural hazards, resulting in continuous damage to property, road infrastructure, and human lives. The risk of landslide susceptibility along a national highway corridor in the lower Himalayan region of Himachal Pradesh, India, is spatially assessed in this study. Seven conditioning factors—average annual rainfall (2016-2026), slope angle, land use/land cover (LULC), distance from roads and rivers, elevation, and slope aspect—were included through the Analytical Hierarchy Process (AHP) within the Google Earth Engine (GEE) cloud computing platform and Geographic Information System (GIS). A continuous Landslide Susceptibility Index (LSI) was developed using an AHP-derived approach. The LSI was then separated into five hazard zones, ranging from Very Low to Very High. The study shows that rainfall (35%) and slope (29%) are the major conditioning factors in the study area, consistent with the monsoon-driven, steep-terrain character of the Lesser Himalayas. The resulting susceptibility map, generated at 30 m spatial resolution, provides a suitable decision-support tool for highway engineers, planners, and disaster management authorities working in this highly vulnerable terrain.

Keywords*:* Landslide susceptibility; Analytical Hierarchy Process (AHP); Google Earth Engine (GEE); National Highway; geospatial analysis; Geographic Information System (GIS).

Geospatial Assessment of Flood Impact, Vegetation Loss, and Landslide Susceptibility in Seobag, Kullu Using Remote Sensing and GIS

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This study presents an integrated remote sensing and GIS-based framework for assessing flood impact, vegetation loss, and landslide susceptibility in the Seobag corridor, Kullu District, Himachal Pradesh. Sentinel-2 multispectral imagery and SRTM Digital Elevation Model (DEM) data were utilized to conduct pre- and post-flood comparative analysis, with preprocessing steps including cloud masking and temporal median compositing to ensure data reliability. The Normalized Difference Water Index (NDWI) was applied to delineate flood extents, revealing that approximately 45.67% of the study area experienced inundation, predominantly along drainage paths and low-lying terrain. Vegetation dynamics were evaluated using the Normalized Difference Vegetation Index (NDVI), with difference mapping indicating extreme vegetation loss across **78.55%** of flood-affected zones, reflecting prolonged waterlogging stress on plant cover. Landslide susceptibility was mapped through slope classification derived from DEM data, identifying high-risk zones on slopes exceeding 30°, covering **39.21%** of the area. A multi-hazard overlay analysis was performed to delineate regions concurrently exposed to flooding, vegetation degradation, and slope instability. All geospatial processing was conducted within the Google Earth Engine (GEE) platform, enabling scalable and efficient analysis. The results confirm that the co-occurrence of surface water accumulation, vegetation loss, and steep terrain significantly amplifies landslide susceptibility, offering actionable insights for disaster risk reduction and sustainable land-use planning in ecologically sensitive Himalayan regions.

A Case Study of the Dharali Flash Flood Using Google Earth Engine

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Using a multi-sensor data fusion approach in Google Earth Engine, this study gives a detailed geographical assessment of the catastrophic Dharali debris flow disaster of 5 August 2025. The event featured six surges that went almost 2,500 m across the Kheer Gad watershed, damaged 70–90% of Dharali village, and formed a ~2 km backwater lake near Harsil. To overcome monsoon cloud-cover limitations, integrated analysis of Sentinel-1 SAR backscatter, Sentinel-2, and Landsat 8/9 spectral indices was performed. Results estimated 203.1 ha of scoured channel area and 1,437.9 ha of affected floodplain. A triple constraint model-based bare soil index detected 0.32 ha of fresh landslide scars, showing channelised mobility of glacio-fluvial moraines rather than extensive hillslope failure. NDVI research found 97 hectares of riparian vegetation loss along the high-velocity flow route. CHIRPS and GPM IMERG precipitation analysis indicated no rainfall on the event day, refuting the cloudburst concept. Instead, antecedent rainfall events induced soil saturation and destabilisation of unconsolidated morainic layers, producing failure. Validation with the USDMA Technical Assessment Report showed 100% agreement across nine key parameters, highlighting the potential of GEE for rapid Himalayan disaster mapping and early warning systems.

Keywords: CHIRPS, Dharali incident, Uttarakhand Disasters, Google Earth Engine, Remote Sensing, SAR Analysis, Antecedent Saturation

Flood Susceptibility Mapping of Beas River Basin, Punjab Using GIS and Remote Sensing

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In the last few decades, flooding events have become more intense and frequent worldwide. Numerous studies have reported an increasing frequency of flood events due to rising global temperatures, changing precipitation patterns, and urbanization in flood-susceptible regions, with this trend floods are predicted to affect around 1 billion people worldwide by 2050. Therefore, the susceptibility to floods must be assessed before the development of civilization in flood-prone areas, as a palliative measure against disasters. In India, the Beas River Basin in Punjab is one of the most vulnerable regions to recurring flood events, especially during the monsoon season. This study aims to make a flood susceptibility map for the Beas River Basin. The influencing factors, namely elevation, curvature, slope, drainage density, rainfall, geomorphology, lithology, and LULC, were used to determine the flood susceptibility. Thematic maps were prepared, and each factor was classified and ranked based on its influence on flood occurrence. The Analytical Hierarchy Process (AHP) was used to determine the weights of selected factors through a pairwise comparison matrix. Pairwise judgments were based on the published previous literature. The obtained weights were then integrated with ranked thematic maps using a GIS-based weighted overlay technique to generate the final Flood Susceptibility Map (FSM), which was classified into five flood-susceptibility zones: very low, low, moderate, high, and very high. The resulting flood susceptibility map showed 10.66% of basin area as least susceptible and 31.48% of basin area as highly susceptible to floods. The final map generated in this study may support flood risk management, land-use planning, and disaster mitigation strategies.

30 Year Siachen Glacier Retreat Analysis

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I perform a multi-decadal glacier inventory of India's Siachen Glacier (East Karakoram) for 1995–2025 using Landsat 5/7/8/9 surface reflectance in Google Earth Engine. The glacier was delineated via NDSI (Normalized Difference Snow Index, (G-SWIR)/(G+SWIR)) thresholding and median composite images (late Ablation, Aug–Sept) to minimise seasonal snow. I converted the resulting pixel counts to area (km²) using ee. Image pixel Area (). Areal extents are 787.51, 872.82, 781.23, and 613.92 km² for year 1995, 2005, 2015, and 2025, respectively. Decadal net changes are +85.31 km² (1995–05 gain), −91.59 km² (2005–15 loss), and −167.31 km² (2015–25 loss), corresponding to +10.8%, –10.5%, and –21.4% change (relative to period start). I present maps highlighting retreat (loss) and expansion (gain) using a color-coded scheme. My analysis accounts for limitations (no debris detection in NDSI, variable cloud cover) and propagates uncertainties via threshold sensitivity tests. The observed pattern initial stability/gain followed by rapid retreat is consistent with recent mass-balance modelling (near-neutral balance until ~2006, then loss), and suggests Siachen is now departing the long-observed "Karakoram anomaly" of glacier stability. These findings have implications for regional hydrology and climate studies.

Understanding Disaster Vulnerability to Enhance Local Disaster Management Systems in Village Thatri, District Kangra, Himachal Pradesh

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Himachal Pradesh is highly vulnerable to natural hazards such as earthquakes, landslides, cloudbursts, flash floods, and forest fires due to its fragile geology, steep terrain, and changing climatic conditions. Kangra district, located in the western Himalayan region, has frequently experienced disaster events that significantly affect rural communities. Village Thatri, situated at 32°13'58.29"N latitude and 76°20'31.36"E longitude, represents a typical Himalayan settlement exposed to high seismic risk and environmental vulnerability. This study assesses disaster vulnerability in Village Thatri through an integrated qualitative and quantitative approach based on the disaster management cycle mitigation, preparedness, response, and recovery. The research examines how physical, social, economic, and institutional factors influence local disaster management capacities and community resilience. Data collection methods include household surveys, key informant interviews, focus group discussions, and analysis of local disaster management practices and policies. According to Gram Panchayat records, the village has a population of 289 people who largely depend on local livelihoods and traditional housing systems. Preliminary findings reveal low levels of disaster awareness, particularly regarding earthquake-resistant construction and safe building practices, despite the village being located in a high seismic zone. Gaps in preparedness, access to disaster-related information, and community-level risk communication were also identified. The study highlights the urgent need for awareness programs, capacity building, and locally suitable disaster risk reduction strategies to strengthen local disaster management systems and improve resilience in disaster-prone Himalayan rural communities.

Forest Fire Risk Zonation for Enhanced Disaster Resilience in Hamirpur District, Himachal Pradesh: An Integrated AHP, Remote Sensing, and GIS Approach

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Forest fire poses ecological, social and economic threats, requiring fire risk zonation for effective disaster management. This study integrates remote sensing and GIS with Analytic Hierarchy Process (AHP). Eight variables including forest cover derived from LULC (Land Use Land Cover), Proximity to roads, LST (Land Surface Temperature), NDWI (Normalized Difference Water Index), NDBI (Normalized Difference Built-up Index), Windspeed, Rainfall and Aspect were analyzed to generate risk map. Risk map indicates that the 14 Km^2 (1.35%) of districts area classified under Very High risk while 217 Km^2 (20.95%) area falls under High risk. The largest portion of study area, covering 590 Km^2 (56.95%), classified as moderate risk. While the Low and Very Low risk zones cover 207 Km^2 (19.98%) and 8 Km^2 (0.77%) area respectively. These results promote the targeted fire prevention strategies by supporting sustainable forest management and regional disaster resilience in direct compliance with SDG-15 (Life on Land).

Keywords: Forest fire risk mapping, Remote sensing, AHP, Disaster risk reduction, Hamirpur

Green Synthesis of tin oxide nanoparticles and Characterization of SnO_2 Nanoparticles Using XRD, FTIR and UV–Visible Spectroscopy

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Tin oxide (SnO_2) nanoparticles were successfully synthesized and characterized using X-ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), and UV–Visible spectroscopy techniques. The XRD analysis confirmed the crystalline nature of the synthesized nanoparticles with prominent diffraction peaks observed at 2θ values of 26.6°, 32.51°, 40°, 49°, 51.47°, and 58.97°, corresponding to the tetragonal rutile phase of SnO_2. The average crystallite size calculated using the Debye–Scherrer equation was found to be in the nanometer range (~4–5 nm), indicating the successful formation of highly crystalline nanoparticles. FTIR analysis revealed characteristic absorption bands at 3672, 1843, 1598, 1089, 746, and 541 cm^{-1}, which confirmed the presence of hydroxyl groups and Sn–O/Sn–O–Sn vibrational modes responsible for nanoparticle formation and stabilization. UV–Visible spectroscopy exhibited absorption peaks at 219 nm and 278 nm, while the absorption edge was observed around 354 nm, confirming the optical activity of the synthesized SnO_2 nanoparticles. The optical band gap energy was estimated to be approximately 3.5 eV, demonstrating the semiconducting nature of the material. The obtained results indicate that the synthesized SnO_2 nanoparticles possess good crystallinity, nanoscale particle size, and promising optical properties, making them suitable for potential applications in environmental remediation, photocatalysis, sensing, and antibacterial activities. The combined characterization results confirm the successful synthesis of SnO_2 nanoparticles with enhanced structural and optical performance.

Antimicrobial Resistance, Virulence, and Mobile Genetic Elements in European *Salmonella enterica*: A Comparative Genomic Study and Its Implications for Human Health

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Fluoroquinolones are becoming increasingly ineffective against Salmonella in Europe. Whole genome sequencing tracks the spread of these threats across food chains and healthcare. Our study aimed to analyse the resistance gene content, virulence gene repertoire, and mobile genetic element (MGE) profile of 67 complete Salmonella genomes from European human clinical isolates. Assemblies came from NCBI GenBank and BV-BRC. Sequence typing used PubMLST. Phylogenetic trees from 16S rRNA sequences used maximum likelihood with 1,000 bootstraps. Antimicrobial resistance genes were identified via CARD, virulence genes via ABRicate/VFDB, and mobile elements via Mobile Element Finder. We detected 22 sequence types (STs) among 67 genomes. ST11 (S. enteritidis) and ST198 (S. kentucky) comprised nearly one-fourth of isolates and formed tight monophyletic clades. Resistance genes for β-lactams, fluoroquinolones, and phenicols were detected, including plasmid-mediated colistin resistance gene mcr-9.1. Core SPI1/SPI-2 virulence genes were conserved. Mobile genetic elements (insertion sequences, composite transposons, MITEs) were widespread and often found near antimicrobial resistance genes. The co-occurrence of last-resort resistance gene mcr-9.1 with a conserved core virulence arsenal in dominant European clinical clones of Salmonella highlights a serious public health threat. Widespread mobile genetic elements located near antimicrobial resistance genes suggest active horizontal transfer and genome plasticity. The tight monophyletic clustering of ST11 and ST198 indicates clonal expansion of high-risk lineages across the continent. These findings underscore the urgent need for integrated genomic surveillance spanning human, animal, and food chain sectors under a One Health framework.

Environmental Genotoxicity and Gynaecological Cancers: siRNA as a precision therapeutic strategy

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Environmental factors are key contributors for the genomic instability and onset of cancers. Around 90% of cancer incidence is associated with environmental and lifestyle factors. The genotoxic agents from industrial pollution, UV-radiations and airborne toxicants are recognised as major contributors to cancer initiation and progression as they induce DNA damage and epigenetic dysregulation. In gynaecological cancers, conventional treatment approaches such as chemotherapy and radiotherapy induce DNA damage to cancerous cells. SIRT7, a multifunctional epigenetic regulator, is observed to be overexpressed in tumor cells, suppressing apoptosis and enabling cancer cell survival through DNA damage repair mechanism. In this study small interfering RNAs (siRNAs) were computationally designed and evaluated as potential therapeutic candidates against SIRT7. *In-silico* analysis confirmed that SIRT7 is overexpressed in tumor samples than normal samples. Six siRNAs (S1-S6) were designed and screened for specificity. Candidate siRNAs and mRNA thermodynamic stability were predicted and siRNAs having optimal GC content and favourable secondary structure were selected for further analysis. Molecular docking and simulation studies revealed interactions of siRNA candidates with human Argonaute 2 (Ago2) protein, maintaining strong post-simulation hydrogen bonds and salt bridges. Both S1 and S6 showed stable interactions with key domains (MID, PAZ and PIWI) of Ago2 protein, highlighting incorporation into RNA induced silencing complex (RISC). Overall, S1 and S6 emerge as promising siRNA candidates for targeting SIRT7. This study highlights the therapeutic potential of siRNA-based gene silencing in gynaecological cancers.

Keywords: Genotoxicity, UV-radiations, siRNA, in-silico

Environmental Chemicals and Altered Microbe–Host Gene Crosstalk Along the Gut–Vaginal Axis in PCOS

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Polycystic Ovary Syndrome (PCOS) is a multifactorial endocrine disorder associated with chronic inflammation, microbial dysbiosis and reproductive complications in women of reproductive age. Environmental factors such as pollution, genotoxins, unhealthy diet and lifestyle affect microbiome of gut and vagina, leading to microbial dysbiosis and alteration in immune system and epithelial barrier function. This study aims to investigate PCOS related gut-vaginal dysbiosis through 16sRNA based analysis and explore its potential link with environmental consequences. Publicly available microbiome dataset comprising of 150 vaginal samples and 311 gut samples from PCOS and healthy control samples were analyzed using 16S rRNA analysis. Relative abundance analysis and shared genera analysis for gut-vaginal interactions were studies to identify microbial alterations associated with PCOS. The analysis revealed microbial imbalance and altered metabolite production linked with host inflammatory and epithelial barrier genes, including IL10, MUC1, CXCL6, and CLDN1. Systems level analysis highlights the association of host genes with environmental pollutants and genotoxic compounds such as bisphenol A, particulate matter, and arsenic, suggesting potential environmental influences on host–microbe interactions. Binding affinity analyses also confirms the binding of pollutants within the pocket residues of host genes. Overall, this study supports gut-vaginal axis in PCOS and suggest genotoxins and environmental exposure affect inflammatory and epithelial barrier genes that indirectly impact women's reproductive health and metabolic dysregulation and microbial dysbiosis.

Environmental Determinants of Female Microbiome and Their Health Implications

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The human microbiome, referred to as the "hidden organ," plays a critical role in maintaining physiological and immunological health. They harbour different sites of human body including oral cavity, lung, gut, skin, vagina etc. Environmental factors are major determinants of female oral, gut and vaginal microbial health. Factors such as diet (processed foods and high-intensity sweeteners), antibiotic use, pollutants like heavy metals (lead, arsenics, cadmium), smoking (nicotine, polycyclic aromatic hydrocarbons), stress, hygiene practices, socioeconomic conditions, hormonal changes, and lifestyle behaviours significantly influence microbial diversity, composition and stability within these body sites. In oral microbiome, environmental influences including tobacco exposure, poor dietary habits and inadequate oral hygiene contribute to microbial imbalance associated with periodontal disease, chronic inflammation, and systemic metabolic disorders. The gut microbiota is particularly sensitive to dietary patterns, environmental toxins, medications and psychosocial stress, with alterations linked to obesity, diabetes and immune dysregulation. Similarly vaginal microbiome is strongly shaped by hormonal status, sexual behaviour, hygiene products, antibiotic exposure, and social and racial determinants of health. Disruptions in vaginal microbiome, especially reductions in *Lactobacillus* dominance, are associated with bacterial vaginosis, sexually transmitted infections, adverse pregnancy outcomes and gynaecological disorders. Therefore, maintaining a balanced microbiome through healthy lifestyle choices, reduced exposure to harmful environmental agents, and personalized healthcare strategies may play a key role in promoting women's health.

Epigenetic Neurotoxicity across Filial generations exposed to Lipophilic Pesticide Pollutants

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The escalating use of lipophilic pesticides globally has raised critical concerns regarding their persistent bioaccumulation and long-term neurological consequences transgenerationally. Due to high lipid solubility and environmental persistence, these chemicals readily accumulate in adipose and neural tissue as they can penetrate blood brain barrier and can therefore interfere with neuronal integrity. Emerging evidences report that chronic exposure to pesticides extend beyond direct neurotoxic effects thus inducing heritable epigenetic modifications which may predispose subsequent generations to neurological dysfunction. The mechanisms leading to these alterations include DNA methylation, histone modifications, chromatin remodeling and dysregulated non-coding RNAs. These modifications implicated in pesticide mediated neurotoxicity disrupt significant molecular pathways that control neuronal differentiation, synaptic plasticity, mitochondrial function, oxidative stress responses and neuroinflammatory signaling. Many experimental studies have further indicated that parental exposure to organochlorines, pyrethoids and organophosphates can induce epigenetic reprogramming in germ cells thereby passing cognitive deficits, behavioral abnormalities and enhanced susceptibility to neurodevelopmental and neurodegenerative disorders in offspring. Recent advances in environmental epigenomics and molecular toxicology provide new insights to mechanistic basis of transgenerational inheritance associated with toxic environmental exposure. Understanding epigenetic markers associated to pesticide induced neurotoxicity facilitate identification of predictive molecular signatures and novel therapeutic targets. There is an urgent need for integrative research approaches employing such methodologies to strengthen public health policies to reduce long term neurological burden levied by chronic pesticide exposure.

Decoding CRISPR-Cas system and their resistance dynamics across the global *Helicobacter pylori* lineages

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The Helicobacter pylori bacterium infects over 50% of the global population and is classified as a WHO Group 1 carcinogen, significantly contributing to gastric cancer through its virulence factors CagA and VacA. New diagnostic and therapeutic methods are crucial as antibiotic eradication rates decline to 70-75%. Although Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)-Cas technologies have advanced bacterial detection and immune understanding, studies exploring CRISPR content, phage interactions, antimicrobial resistance, and lineage diversity in H. pylori are limited. In the study, 1,805 H. pylori genomes from NCBI were analyzed to reconstruct CRISPR-Cas systems and resistance patterns. Out of these, 1,676 genomes with CRISPR and 8,301 spacers were identified using CRISPRCasFinder. BLASTn comparison to the NCBI Viral Database found 107 hits at 100% identity across 35 phages, indicating active phage immune memory. A pan-genome analysis of 306 genomes with Prokka and Roary showed high plasticity: 93.2% cloud genes and 0.55% core genes. Among 306 sequence types, 78.8% were new, highlighting gaps in understanding H. pylori diversity, especially in Indian and Asian lineages. Core genome phylogeny revealed lineage-specific clustering, with 265 of 306 strains being CRISPR-positive, suggesting differences in immune strategies. Defence systems beyond CRISPR were identified, including 17 types. ARG profiling identified 9 major resistance genes-vanT, vanTr, hp1181, frxA, rdxA, pbp1, pbp2, 23S rRNA, and rpoB-with CRISPR (+) strains showing significantly higher AMR gene burden ($p = 0.0028$), providing the first large-scale genomic evidence of a CRISPR–AMR fitness trade-off in H. pylori. The results show that CRISPR status guides antibiotic choices, novel sequence data enable global diagnostics, and 35 validated phages are promising for phage therapy when antibiotics fail. It also supports multi-target drug design against H. pylori's immune and resistance systems, reducing H. pylori-related gastric cancer risk.

A Pan-genome Approach to Uncover Lineage-Specific Genomic Signatures of Virulence and Antimicrobial Resistance in *Neisseria gonorrhoeae*

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Multidrug-resistant (MDR) and extensively drug-resistant (XDR) *Neisseria gonorrhoeae* pose global health challenges as resistance to nearly all antibiotics used for gonorrhoea increases. MDR strains resist multiple first-line antibiotics, while XDR strains also show reduced susceptibility to extended-spectrum cephalosporins, raising fears of untreatable infections. *N. gonorrhoeae* is a Gram-negative, human-specific diplococcus causing urogenital, rectal, and pharyngeal infections. Its high genomic plasticity, recombination, and diverse accessory genome complicate SNP-based surveillance and hinder understanding of lineage-specific resistance development. This study used a lineage-specific pan-genome approach to explore gene content, Multi-locus Sequence Typing (MLST) lineages, AMR genes, and virulence factors in high-risk lineages, especially ST 7363 and ST 1901. From NCBI, 277 complete genomes with metadata were analysed using Prokka for annotation, Roary for pangenome construction, MLST for typing, and AMRFinderPlus and ABRicate (VFDB) for detecting AMR and virulence genes. The pan-genome contained 8,117 genes: 086 core, 806 shell, and 225 cloud, indicating high diversity. The genomes spanned 86 types and one unassigned lineage, with 22 AMR gene families (67 variants) and 16 virulence gene families (50 variants). High-risk lineages ST-1901 (19 isolates, 8 countries) and ST-7363 (29 isolates, 7 countries) and harboured key resistance genes (penA, gyrA, parC, ponA, porb, folP, rpsJ, MtrCDE) conferring resistance to β-lactams, quinolones, macrolides, tetracyclines, sulfonamides, and rifamycins. All isolates showed XDR profiles, indicating globally spread high-risk clones. This research improves understanding of MDR/XDR *N. gonorrhoeae* and supports better surveillance and treatment development.

Deciphering Multi-Target Regulatory Mechanisms of *Bauhinia variegata* for Polycystic Ovarian Syndrome Management: A System Pharmacology and Pharmaco-Transcriptomic Analysis.

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Polycystic Ovarian Syndrome (PCOS) is a neuroendocrine disorder, affecting 8-13% of reproductive-aged females. Lifestyle alterations and environmental factors lead to PCOS in females. PCOS is characterised by Symptoms like Oligo-anovulation, Hirsutism, Infertility, Insulin resistance, etc. Current Treatment temporarily relieves symptoms without a permanent cure, necessitating a safer, multi-level approach. In the current Study, the therapeutic efficacy of the *Bauhinia variegata* plant in treating PCOS and its comorbidities was studied using a multi-omics system-level approach, combining differentially expressed genes (DEGs) and exosomal microRNAs (miRNAs) of PCOS. A dataset of phytochemicals from *Bauhinia variegata* (BVPCs) was generated (n = 111)

using online databases, and target prediction, ADMET screening, chemical clustering, drug-similarity analysis, binding-energy evaluation, and multi-layered network analysis were performed. A total of 571 DEGs and exosomal miRNAs were identified after thorough Transcriptomic profiling, revealing 92 key BVPCs, including hesperidin, apigenin, naringenin, and podophyllotoxin derivatives, as regulatory bridges linking miRNA dysregulation and gene expression. Toxicity, drug-similarity analysis confirmed that most BVPCs have low predicted toxicity and possess structural similarities to 50 FDA-approved drugs. Key BVPCs, viz., hesperidin, Bauhiniastansin, and bauhinols, revealed strong interactions with neprilysin enzyme, a key PCOS-related comorbid protein, after Protein-protein interaction, network pathway enrichment, and molecular docking. The binding affinities of BVPCs (range -5.4 to -9.6kcal/mol) with PCOS and its comorbid protein targets indicate a potential role in PCOS metabolic regulation and also suggest they could serve as bioactive scaffolds. The results identify BVPCs as promising multi-target agents for PCOS, offering new insights into Bauhinia's therapeutic journey.

Keywords: Bauhinia variegata, Polycystic Ovary Syndrome (PCOS), Exosomal miRNA, Differential gene expression, Systems pharmacology, and comorbidity

Standardization of the *allium cepa* cytogenetic assay for environmental monitoring and genotoxicity assessment

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In the modern era, exposure to various environmental pollutants and the use of emerging contaminants increase the risk of genetic instability, necessitating timely health assessments to address late genotoxic consequences. Despite regulatory recommendations, many genotoxicity test batteries have not been adopted to assess the genotoxicity of chemicals due to their lengthy culturing process, high cost, inadequate containment, and need of skilled personnel. Therefore, a simple, sensitive, and reliable biomarker is required that can be performed in field conditions and basic low-infrastructure settings with minimal ethical constraints. The *allium cepa* test is a widely used and cost-effective model for assessing cytogenotoxicity by observing root growth changes and the mitotic index. The present study focuses on standardisation of cytogenetic assay, using root apical meristem of *Allium cepa* as a model system for monitoring and environmental genotoxicity. *Allium cepa* is suitable because of features such as large, well-defined chromosomes, rapid root growth, and a high mitotic index. The actively growing root tips were collected and subjected to standardised cytogenetic procedures, including cell fixation, acid hydrolysis, staining, and slide preparation. To identify different stages of mitosis, slides were examined under a light microscope. To evaluate cellular growth and genotoxic effects of a substance, the mitotic index and chromosomal abnormalities were recorded in the cells. The potential genomic damage caused by environmental contaminants is proven by variations in the mitotic index and increased frequency of chromosomal aberrations. The assay standardisation ensures accuracy of steps, reliability, and reproducibility of cytological observations. The findings further validate that *Allum Cepa assay* is an effective and eco-friendly tool for environmental monitoring, pollution examination, and cytogenetic research.

Sustainable Design of Schiff Base Functionalized Graphene Oxide (GO-IFS) As a Hybrid Platform for Waste Water Treatment

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In the present study, a novel Schiff base functionalized graphene oxide
nanomaterial (GO-IFS) was successfully synthesized, characterized, and evaluated for photocatalytic degradation of organic pollutants under visible light irradiation. The Schiff base ligand (IFS), derived from the condensation of 4-hydroxyacetophenone and 4-nitroaniline via ultrasonication, was covalently immobilized onto the graphene oxide surface through ester linkage formation between the hydroxyl groups of IFS and the carboxylic acid groups of GO. The successful functionalization of the GO-IFS composite was confirmed by FT-IR, XRD, FE-SEM, and EDX analyses, which collectively verified the structural modification, surface morphology, and elemental composition of the synthesized nanomaterial. Graphene oxide serves as an effective support matrix owing to its high specific surface area, mechanical stability, and abundant oxygen containing functional groups that facilitate covalent anchoring of the Schiff base ligand. The incorporation of Schiff base moieties significantly enhanced the structural tunability, visible light absorption, and charge separation efficiency of the composite through the electron donating and withdrawing character of the imine linkage (-C=N-). The synthesized GO-IFS nanomaterial exhibited enhanced photocatalytic activity toward the degradation of crystal violet (CV) dye, which was systematically evaluated under varying operational parameters, including adsorbent dosage, solution pH, and contact time. The results clearly indicate that these parameters significantly influence the photocatalytic performance of the material. Optimal degradation efficiency of approximately 74.8% was achieved using 20 mg of catalyst in 20 mL of dye solution within 10 min. The observed high efficiency can be attributed to the synergistic effects of improved adsorption and enhanced charge transfer properties of the GO-IFS composite. These results demonstrate the potential of GO-IFS nanoparticles as efficient and ecologically1 friendly photocatalysts for the elimination of dangerous organic dyes from aqueous systems, providing prospective uses in environmental remediation.

Gum acacia graphene-oxide hydrogel composite for removal of dye from wastewater

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In this study, a gum acacia-graphene oxide (GO) based hydrogel composite was formed as eco-friendly and effective adsorbent for the removal of malachite green dye from wastewater. The hydrogels were synthesized via chemically induced free radical copolymerization method by the use of GA, GO, polyvinyl alcohol (PVA), acrylic acid (AA), with potassium persulfate (KPS) as the initiator and N, N'-methylenebisacrylamide (MBA) as the crosslinker. The surface morphology, thermal stability, and crystalline structure of the prepared hydrogel were characterized via FTIR (Fourier Transform Infrared Spectroscopy), TGA (Thermogravimetric Analysis), SEM (Scanning Electron Microscopy), and XRD (X-ray Diffraction). The presence of functional groups confirmed by the FTIR, XRD analysis verified the amorphous nature of the composite, while SEM images showed a rough and heterogenous surface morphology, which is highly favorable for adsorption study and dye removal. TGA analysis confirmed that the hydrogel composite showed good thermal stability up to 200ºC, making it suitable for environmental conditions. Furthermore, the adsorption study showed maximum removal efficiency of malachite green dye reached up to 74% at 6ppm concentration using 300mg hydrogel composite. These findings showed that synthesized hydrogel is an environmental friendly, cost-effective, and promising material for the effective dye degradation from wastewater.

Gum acacia hydrogel for adsorptive removal of malachite green dye

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The discharge of synthetic dyes, particularly from textile industries, has emerged as a serious environmental issue due to their persistence, toxicity, and resistance to conventional wastewater treatment processes. These dyes reduce light penetration in aquatic systems, adversely affecting aquatic life and posing potential health risks to humans. Therefore, the development of efficient, eco-friendly, and cost-effective materials for dye removal is highly essential. In the present study, a novel polymeric hydrogel based on Gum Acacia and polyvinyl alcohol (PVA) was synthesized and evaluated for the adsorptive removal of malachite green dye from aqueous solutions. The hydrogel was prepared using distilled water as a solvent, acetic acid as a catalyst, N, N'-methylenebisacrylamide (MBA) as a cross-linking agent, and potassium persulfate (KPS) as an initiator for polymerization. The resulting hydrogel was designed to enhance adsorption efficiency through its porous and cross-linked structure. The synthesized material was characterized using various analytical techniques. Fourier Transform Infrared Spectroscopy (FTIR) confirmed the presence of functional groups and successful polymer network formation. Scanning Electron Microscopy (SEM) revealed a porous surface morphology favorable for dye adsorption. Thermogravimetric Analysis (TGA) demonstrated good thermal stability, while X-ray Diffraction (XRD) analysis indicated the structural nature of the hydrogel. The results showed that the prepared hydrogel possesses desirable structural properties, significant thermal stability, and enhanced adsorption capacity. The presence of active functional groups and a well-developed porous network contribute to its high efficiency in dye removal. Overall, the Gum Acacia–PVA hydrogel demonstrates strong potential as an environmentally friendly and effective material for wastewater treatment applications.

Bioremediation of Norfloxacin Using a Bacterial Isolate from Poultry Farm Soil

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Antibiotics constitute a vital therapeutic cornerstone in the global management of bacterial infections. Fluoroquinolones represent the second most consumed antibiotic class worldwide, with norfloxacin among the most frequently prescribed agents in India. However, its incomplete metabolic clearance and environmental persistence have raised substantial ecotoxicological concern, particularly regarding the propagation of antimicrobial resistance (AMR) across agricultural and aquatic ecosystems. This study aimed to evaluate the norfloxacin-degrading capacity of a bacterial isolate recovered from poultry farm soil and to characterize its putative enzymatic degradation pathway. This study aimed to evaluate the norfloxacin-degrading capacity of a bacterial isolate recovered from poultry farm soil and to characterize its putative enzymatic degradation pathway. The bacterial isolate was obtained via serial dilution and standard streak-plate isolation. The isolate was subsequently subjected to a 7-day batch degradation assay at an initial norfloxacin concentration of 30 mg/L under 37ºC and aerobic conditions. Enzymatic profiling encompassed cytochrome P-450 and esterase activity assays, alongside carbohydrate fermentation profiling for biochemical characterization. The isolate demonstrated a norfloxacin degradation efficiency of 75% over the experimental period. Esterase activity was detected, thereby implicating a potential degradation pathway. The findings indicate that bacteria derived from poultry soil could serve as a promising and environmentally sustainable solution for the bioremediation of environments contaminated with fluoroquinolone pharmaceutical waste.

Bioremediation of Ofloxacin By A Poultry Soil Isolate: Potential For Remediation Of Fluoroquinolone-Impacted Environment

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Antibiotics are used for their bactericidal and bacteriostatic effects, but are emerging pollutants due to incomplete metabolization. Fluoroquinolones are among the most consumed groups of antibiotics globally. These antibiotics are used to treat various diseases like gastrointestinal, respiratory, urinary, and sexually transmitted diseases because of their impressive oral bioavailability and tissue penetration. Fluroquinolones are associated with adverse side effects such as tendon rupture, peripheral neuropathy, and mitochondrial toxicity. Ofloxacin is recalcitrant and frequently detected globally, entering the environment unchanged and posing lethal effects on soil and aquatic biota and promoting antibiotic resistance genes (ARGs). Since conventional methods are inefficient, bioremediation is necessary for sustainable removal. In this study, a bacterial species was isolated from poultry soil consortia contaminated by fluoroquinolones. UV-spectrophotometric analysis of the 7-day degradation assay showed 62% drug removal from the initial concentration of 30mg/L. Enzymatic characterization revealed the presence of esterase activity in the bacterial isolate, suggesting that esterase-mediated hydrolysis played a role in the degradation pathway of ofloxacin. Temperature characterizations demonstrated the bacterial isolate's growth at 28°C and 37°C, while no growth was observed at 0°C and 55°C, indicating that the bacterial isolate is mesophilic in nature. These findings highlight the consortia-derived isolated strain’s potential to act as an efficient tool for bioremediation of fluoroquinolone-contaminated environments.

Synthesis of $NiTiO_3$ Photocatalyst through Sol–Gel Technique for Efficient Sunlight-Driven Degradation of Crystal Violet Dye

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Nickle Titanate ($NiTiO_3$) nanoparticles were successfully synthesized via a sol - gel method and evaluated for its photocatalytic activity toward crystal violet dye degradation under sunlight irradiation. The formation of crystal structure of $NiTiO_3$ nanoparticles was confirmed by using X-ray diffraction (XRD) which showed an average crystallite size of approximately 66 nm. The morphology and optical characteristics of the synthesized $NiTiO_3$ nanoparticles were characterized by using ultraviolet visible (UV- Vis) and Scanning Electron Microscope (SEM). SEM analysis revealed that the synthesized $NiTiO_3$ possesses agglomerated and porous nanoparticles with irregular granular morphology and rough surface texture. The XRD, UV-Vis and SEM results confirmed the synthesis of $NiTiO_3$. The UV-Vis spectroscopy shows the maximum absorbance with the band gap of 2.2 eV. In photocatalytic degradation experiment, $NiTiO_3$ shows the photocatalytic activity and it was evaluated through the degradation of crystal violet (CV) dye under sunlight irradiation, achieving 96.8% degradation within 210 minutes. Overall, the results suggest that the synthesized $NiTiO_3$ nanoparticles is an efficient photocatalyst for dye degradation and it is also cost effective and has good potential for wastewater treatment applications.

EGCG/ECG-controlled mesoporous and ultrafine TiO_2 nanoparticles for UV-driven pollutant mineralization and radical scavenging

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We report the first phytochemical-guided, one-pot sol–gel/hydrothermal synthesis of mesoporous anatase TiO_2 nanoparticles (<10 nm) directed by catechin-rich fractions (epigallocatechin-3-gallate (EGCG), epicatechin-3-gallate (ECG), epigallocatechin (EGC)) identified through GC-MS of a *TV-26 Camellia sinensis* extract. These small-molecule bio-templates drive uniform Ti^{4+} nucleation, arrest crystal growth, and remain grafted to the oxide surface, producing a high specific surface area (160 $m^2\ g^{-1}$) and a stable polyphenol corona. Comprehensive characterization (XRD, UV–Vis-DRS, FTIR, BET, SEM/TEM) confirms the phase-pure anatase and a narrow size distribution (6–9 nm). The bio-templated TiO_2 attains >98 % mineralization of methylene blue under near-UV irradiation (365 nm, 65 mW cm^{-2}) within 45 min, giving a pseudo-first-order rate constant k = 0.0567 min^{-1}, more than double that of commercial P25 under identical conditions. Surface-bound catechins impart intrinsic antioxidant activity, with IC_{50} values of 34.7 ± 1.2 µg mL^{-1} (DPPH) and 29.3 ± 0.9 µg mL^{-1} (ABTS). By uniting green synthesis, size-controlled microporosity, and dual photocatalytic/radical-scavenging functionality, this work positions phytochemical-engineered TiO_2 as a versatile platform for next-generation water remediation and biomedical technologies.

Study on Environment Pollution and Bioremediation in India

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Environmental pollution has become a major global concern due to rapid industrialization, urbanization, and excessive use of chemicals, leading to contamination of soil, water, and air. Traditional methods of pollution control are often expensive and may create secondary pollutants. This study focuses on understanding the role of bio-remediation in controlling environmental pollution and promoting sustainable environmental management. The research highlights various types of pollutants and examines how biological agents can effectively degrade toxic substances and restore ecological balance. Data was collected from secondary sources such as research articles, environmental reports, journals, books, and government publications related to pollution control and bioremediation technologies. Comparative analysis was conducted to evaluate the effectiveness of different bio-remediation methods such as phytoremediation, microbial remediation, and micro mediation. The study also reviews case studies from different countries to understand practical applications and challenges associated with bioremediation techniques. The findings of the study reveal that bio-remediation is an efficient, sustainable, and environmentally safe approach for reducing pollution levels in contaminated sites. The study implies that increased awareness, government support, and technological advancements can promote wider adoption of bioremediation methods. Furthermore, integrating bio-remediation into environmental policies can contribute significantly to sustainable development and long-term ecological conservation. Bio-remediation is an effective and eco-friendly solution for controlling environmental pollution. It helps in reducing harmful contaminants naturally while supporting environmental sustainability. The study concludes that wider use of bioremediation techniques, along with proper awareness and policy support, can play an important role in protecting and restoring the environment for future generations.

Sustainable TiO_2-Embedded Guar Gum–Sodium Alginate Hydrogel for Crystal Violet Dye Adsorption

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Synthetic dye pollution has become a serious environmental challenge due to the toxicity and persistence of dyes in aquatic systems. In this study, a biodegradable hydrogel nanocomposite, GG-SA@TiO_2, was synthesized using guar gum and sodium alginate as polymeric matrices and TiO_2 nanoparticles as a reinforcing adsorptive material for the removal of crystal violet (CV) dye from water. The hydrogel was fabricated through combined ionic and covalent crosslinking techniques to obtain a stable network structure. Batch adsorption experiments were carried out to evaluate the effects of adsorbent dosage, dye concentration, pH, temperature, and interfering ions on CV adsorption. The synthesized nanocomposite exhibited a maximum adsorption capacity of 8.589 mg g^{-1}. Adsorption kinetics followed the pseudo-second-order model, indicating that the adsorption process was mainly governed by surface interactions. Equilibrium studies showed better fitting with the Freundlich isotherm model, suggesting heterogeneous and multilayer adsorption behaviour. The enhanced adsorption performance was attributed to electrostatic attraction, hydrogen bonding, π–π interactions, and surface adsorption mechanisms. Furthermore, the hydrogel nanocomposite demonstrated appreciable regeneration and reusability, indicating its potential as an eco-friendly and efficient adsorbent for wastewater treatment applications involving dye contaminants.

Ecotoxicology Of Pesticides In Aquatic Ecosystems: Mechanisms, Impacts, And Remediation

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While essential for modern agriculture, pesticides pose serious threats to aquatic ecosystems, non-target animals, and humans. Pesticides damage fish DNA and chromosomes, causing permanent genetic changes and population decline. EDCs disturb hormonal systems, affecting reproduction and immunity. Many studies on *Rhamdia quelen*, *Nile tilapia*, and *Labeo rohita* have shown that fish immunotoxicity causes altered leukocyte profiles, increased oxidative stress, and organ damage. Pesticides alter fish reproductive axis, causing steroid hormone production and transgenerational fertility issues. Pollinators, birds, beneficial insects, and aquatic life are harmed by pesticides. The effects include endocrine disruption, teratogenicity, behavioral abnormalities, and population decline. Herbicides including atrazine, glyphosate, and endosulfan inhibit algae development, oxidative stress, and photosynthesis, changing food chains. Pesticide exposure may cause headaches, respiratory irritation, cancer, neurological, infertility, and developmental defects. Agriculture workers and newborns are most at risk from pesticides, which enter the body by inhalation, skin contact, or food and water contamination. Addressing these risks requires integrated methods. Chemical degradation methods like enhanced oxidation, biological remediation with microorganisms and enzymes, mechanical methods like pruning and burning, and Integrated Pest Management (IPM) with biological, cultural, and minimum chemical controls are preventive. These methods decrease pollution, protect public and ecological health, and preserve agricultural productivity.

Synthesis and Characterization of Cadmium-Doped MoS_2 for Enhanced Metal Ion Sensing Applications

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The study presents the synthesis of molybdenum disulfide (MoS_2) and its cadmium-doped variant (Cd–MoS_2) to enhance functional properties. Both materials were produced through a Hydrothermal method and characterized by various analytical techniques such as XRD, FTIR etc. to assess their structural, morphological, and optical features. Comparative analysis confirmed successful cadmium doping and its effect on the material's behaviour. The Cd–MoS_2 exhibited improved sensitivity and selectivity, indicating its potential as an effective metal ion sensor. Current efforts are aimed at evaluating its capability to detect trace metal ions, emphasizing its promise for environmental monitoring and analytical sensing applications.

Engineering a Heterojunction for Efficient Visible-Light Photocatalytic Degradation of Environment Pollutant

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The development and application of heterojunction photocatalysts for environmental remediation have emerged as a promising research area, although several limitations persist. In this study, a CCTO/g-C_3N_4 (CCTO/CN) heterojunction was successfully synthesized to enhance photocatalytic performance under visible light irradiation. The integration of a perovskite ($CaCu_3Ti_4O_{12}$) was done with graphitic carbon nitride which was successfully achieved via a hydrothermal approach. Moreover, the Structural, morphological and optical properties of the prepared composite were systematically characterized using XRD, UV-vis and FTIR, confirming the successful formation of a well-integrated heterojunction. The heterostructure exhibited a significantly enhanced photocatalytic activity towards Congo red dye degradation under visible light irradiation. Moreover, the improved performance is attributed to the formation of an efficient heterojunction interface, which promotes charge carrier migration while preserving sufficient redox potential for photocatalytic reactions. Overall, this work highlights the potential of CCTO/CN heterojunctions as promising photocatalysts for the removal of organic pollutants and contributes to the development of sustainable environmental remediation techniques.

Keywords: Heterojunction, Photocatalyst, Graphitic Carbon Nitride, Calcium Copper Titanate

Malic Acid Crosslinked Chitosan Hydrogel for Congo Red Removal: Adsorption Isotherm, Kinetics and Thermodynamic Studies

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Chitosan malic acid hydrogel (Ch-Ma) was synthesized to successfully remove Congo red dye (CR) using a solution mixing and precipitation technique. The hydrogel synthesis was verified using Brunauer-Emmett Teller, FESEM- EDS, thermogravimetric analysis, and Fourier transform infrared spectroscopy. Chitosan: malic acid 2:1 (Ch-Ma-II) has a higher swelling percentage than other compositions of chitosan malic acid, according to swelling studies. In a batch experiment, Ch-Ma-II hydrogels showed a strong capacity to adsorb CR dye. Adsorption tests revealed that under optimal conditions- 0.1g of adsorbent dose, 5mg/L dye concentration, neutral pH, and temperature 25 °C, the hydrogel eliminated the dye. The Langmuir isotherm and pseudo-Second- order model provide the best explanation for the hydrogel adsorption, and the maximum adsorption capacity was found to be 26.52 mg/g. The thermodynamics study verified that the process was spontaneous and exothermic (ΔH =25.35 kJ mol^{-1}). Strong adsorption capabilities were seen using the Ch-Ma-II hydrogel even after four consecutive cycles.

Keywords: Chitosan; Hydrogel, Adsorption; Spontaneous.

Evaluating the Benzene Removal Efficiency of *Ficus elastica* in Closed-Chamber Conditions

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Indoor air pollution, particularly from volatile organic compounds (VOCs) such as benzene, has emerged as a major global health concern due to prolonged human exposure in poorly ventilated environments. Benzene, a Group 1 human carcinogen, is widely emitted indoors from paints, furniture, and combustion sources, posing serious risks even at low concentrations. The study was carried out to investigate the phytoremediation potential of Ficus elastica (rubber plant) for benzene removal under indoor conditions using a controlled closed acrylic glass chamber system. Ficus elastica plants were exposed to an initial benzene concentration of 5000 ppb in closed chambers, and benzene levels were continuously monitored using an indoor air quality analyzer. Three setups using one, two, and three plants were employed to assess the impact of plant density on removal efficiency. Results revealed a dose-dependent reduction in benzene, with up to 93.86% removal achieved within 88 hours using a single plant, and up to 92.20% removal within just 48 hours using three plants. Morphological assessments confirmed the plants' tolerance, with no chlorosis, necrosis, or growth impairment, even under high benzene stress. Furthermore, headspace gas chromatography–mass spectrometry (GC–MS) analysis of leaves and roots identified several benzene-derived metabolites absent in control plants, confirming active uptake and metabolic transformation of benzene through biochemical pathways. These findings highlight Ficus elastica as a resilient, effective, and sustainable phytoremediation candidate capable of significantly improving indoor air quality. With its ornamental value, ease of cultivation, and adaptability to low-light conditions, the species offers a practical and low-cost alternative to conventional air purification systems, especially in VOC-burdened or poorly ventilated spaces. Beyond confirming benzene removal efficiency, this study provides mechanistic evidence of in planta detoxification, positioning Ficus elastica as a strong candidate for integration into green building practices and urban indoor pollution management frameworks.

Interaction of Pine Needles Biomass with Carbonic Anhydrase Enzyme

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Carbonic anhydrase (CA) is a zinc-containing metalloenzyme that catalyzes the reversible conversion of carbon dioxide to bicarbonate ions, playing a vital role in pH regulation, respiration, and carbon metabolism. In this study, enzymatic activity of carbonic anhydrase was evaluated before and after exposure to the biomass-derived fuel gas using Wilbur Anderson assay and carbonation protocols. Essential oil was first extracted from pine needle biomass as a preliminary processing step, yielding a biomass residue enriched in structural and organic compounds. This post-extraction biomass was subsequently employed as the primary substrate for treating fuel gas generated through thermal processing. The resultant fuel gas, was then passed through a reaction system to assess its influence on the functional behaviour of the selected carbonic anhydrase enzyme. The stability of the enzyme system was further examined upon exposure to flue gas to determine whether the enzyme remains active or is inhibited under such stress conditions. The behaviour of carbonic anhydrase under flue gas exposure is of significant importance in environmental biotechnology, as flue gas represents a realistic industrial emission stream containing CO_2, SO_2, and other trace gases. These components may influence the stability and catalytic efficiency of the enzyme, thereby affecting its overall performance in carbon capture applications.

Keywords: Carbonic anhydrase, pine biomass, carbon sequestration, esterase activity, fuel gas, enzyme activity.

Interaction of Pine Biochar with CA Carbonic Anhydrase: implication for Carbon Sequestration

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The study focuses on bacterial isolates obtained from cow dung, a rich and diverse microbial source, to explore their potential carbonic anhydrase (CA) activity. The samples are being processed to isolate and culture bacteria, and the identified isolates are being screened to determine efficient CA-producing strains for further investigation. The extracted enzyme is being studied for its interaction with oil-extracted lignocellulosic biochar, with the aim of developing a stable and reusable enzyme–biochar system for carbon sequestration applications. Enzyme immobilization onto biochar is being explored to enhance catalytic efficiency and operational stability. Carbonic anhydrase activity is being evaluated using multiple analytical approaches. The esterase activity assay using p-nitrophenyl acetate (p-NPA) is being employed as a rapid colorimetric technique to assess enzyme functionality. In addition, a colorimetric carbonation assay using calcium chloride ($CaCl_2$) is being used to monitor CO_2 hydration activity under controlled conditions. To further simulate practical applications, a fuel gas exposure method is being incorporated, where gas streams are passed through the enzyme-biochar complex to evaluate its functional performance and stability. This study is expected to provide insights into enzyme–biochar interactions and contribute toward the development of sustainable, bio-based strategies for carbon capture and sequestration.

Keywords: Carbonic anhydrase, cow dung bacteria, biochar, enzyme immobilizations, carbon sequestration, calcium carbonate precipitation, CO_2 hydration.

Exploring the potential of *Lantana camara* as an ecofriendly biosorbent for heavy metal remediation: A review

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Rapid industrialization and urbanization have caused extensive heavy metal pollution in water bodies, creating major environmental and health threats due to their toxic, non-biodegradable and bioaccumulative nature. Traditional approaches for heavy metal removal, such as chemical precipitation, ion exchange, membrane filtration, and electrochemical techniques, are often costly and can produce secondary pollutants. Therefore, the development of economical, efficient and environmentally friendly alternatives is necessary. Biosorption using plant-derived biomass has gained increasing attention as an alternative to traditional methods, as it is cost-effective and eco-friendly in nature. Among different plant biomasses, *Lantana camara* has gained significant attention as a promising biosorbent in recent years. *Lantana camara* is an aggressive invasive weed widely distributed across tropical and subtropical regions. It is cost-effective and rich in lignocellulosic components and surface functional groups, which facilitate metal binding, making it a promising biosorbent. These functional groups improve their ability to bind and remove metal ions from contaminated water via mechanisms such as adsorption and ion exchange. The adsorption performance is affected by various factors, such as pH, biosorbent dosage, contact time, temperature, and initial metal concentration. This review critically examines the potential of *Lantana camara* biomass as a biosorbent for the removal of heavy metals from aqueous solutions. Overall, this review emphasizes the potential of *Lantana camara* as a sustainable, cost-effective biosorbent for heavy metal removal and its possible role in environmental remediation strategies.

Temporal variation in physicochemical characteristics of Baner khad and Jogal khad, Kangra, Himachal Pradesh

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The study focus on Baner Khad and Jogal Khad which flows through Nagrota Bagwan region of Kangra district of Himachal Pradesh. The objective is to study the temporal variation in physicochemical characteristics i.e. pH, electrical conductivity (EC), total dissolved solids (TDS) and salinity of water of each khad. Sampling was carried out on weekly basis from September 2025 to April 2026 at same site on each khad and samples were tested for their physicochemical characteristics using a digital multiparameter probe. The pH remained near neutral i.e., 6.9 – 7.9 (avg 7.4) in Jogal khad and 7.0 – 7.9 (avg 7.4) in Baner Khad. In Jogal Khad, EC and TDS values varied from 375.3 µS and 266 ppm during September 2025 to 217.7 µS and 153.3 ppm in February-March 2026, while salinity decreased from 0.19 to 0.12 ppt. In Baner khad, highest EC and TDS values were found to be 373.3 µS and 265 ppm in September 2025 and lowest values of 218.3 µS and 154.7 ppm in December 2025. Salinity decreased from 0.19 ppt to 0.12 ppt. On an average EC, TDS and salinity values were found be relatively higher for Baner khad than the Jogal khad. The observed variations can be attributed to differential contribution from increased runoff during rain, glacial melt water during summer, and anthropogenic activities in the catchment of each khad. The studied parameters were found to be within permissible limit as per Bureau of Indian Standards.

Keywords: Baner Khad, Jogal Khad, Physicochemical characteristics, Water.

Role of EDTA in Justifying the Significance of Carbonic Anhydrase for Carbon Capture

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Carbonic anhydrase (CA) is a metalloenzyme, catalyzes the reversible hydration of CO_2 to bicarbonate and a promising biocatalyst for carbon capture applications. There are some limitations towards justifying the role of CA in the above application due to crude form. It was proposed to be justify by using EDTA as Inhibitor. In the present study, bacterial strains were isolated from cow dung and geothermal biofilm samples, and purified through successive streaking techniques. The enzymatic activity of carbonic anhydrase was evaluated using UV–visible spectrophotometry at 550 nm, using phenol red as a pH-sensitive indicator to monitor CO_2 hydration kinetics. Comparative experiments were planned with or without involving ethylenediaminetetraacetic acid (EDTA) as an inhibitor with free enzyme and immobilized enzyme. Overall, the findings highlight the potential of extracted carbonic anhydrase as an effective biocatalyst for CO_2 sequestration

Keywords: Carbonic anhydrase, CO_2 sequestration, Enzyme immobilization, Sodium alginate, EDTA inhibition, Carbon capture, Microbial enzyme activity, Phenol red assay, UV-Visible spectrophotometry, Enzyme kinetics, Environmental biotechnology.

Environmental Water as a Reservoir of Antibiotic-Resistant Bacteria: Isolation and Phenotypic Characterization of Diverse Microbial Isolates

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The emergence and dissemination of antibiotic-resistant bacteria (ARB) in environmental settings have become a critical concern for global public health. Aquatic ecosystems, in particular, serve as dynamic reservoirs facilitating the persistence and spread of resistant microorganisms. In the present study, six environmental water samples were collected and subjected to microbiological analysis to isolate and characterize potential ARB. Bacterial colonies were recovered by spread plate technique at three different concentrations. Morphologically distinct colonies were selected and purified using streak plate method, resulting in a total of 42 bacterial isolates. Phenotypic characterization was performed based on colony morphology. Gram staining, virulence assay and a series of biochemical assays including catalase, oxidase, citrate utilization, urease activity, indole production, and triple sugar iron (TSI) tests were performed. The isolates exhibited considerable diversity in colony characteristics such as size, pigmentation, margin, and elevation. Biochemical profiling further demonstrated significant metabolic variability among the isolates. Preliminary screening on antibiotic-supplemented media indicated the presence of potential antibiotic-resistant bacteria within these environmental samples. Although detailed quantitative susceptibility testing was not conducted, the observed growth patterns suggest that aquatic environments may act as reservoirs of resistance traits. Overall, this study provides a foundational phenotypic insight into environmental bacterial diversity and highlights the potential role of water sources in harbouring antibiotic-resistant bacteria. These findings establish a basis for future molecular characterization and in-silico analysis of antibiotic resistance genes (ARGs) to better understand resistance dissemination in environmental systems.

Environmental Pollution and Bioremediation

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Environmental pollution has emerged as one of the major global challenges affecting human health, biodiversity, and ecological balance. Rapid industrialization, urbanization, agricultural activities, and improper waste disposal have led to the contamination of air, water, and soil with harmful pollutants such as heavy metals, pesticides, plastics, petroleum hydrocarbons, and toxic chemicals. These pollutants not only degrade natural resources but also pose serious risks to living organisms and sustainable development. Conventional methods of pollution control, including chemical and physical treatments, are often expensive and may generate secondary pollutants. Bioremediation has gained importance as an eco-friendly, cost-effective, and sustainable approach for the treatment of polluted environments. It involves the use of microorganisms, plants, fungi, or biological enzymes to degrade, detoxify, or remove contaminants from soil, water, and air. Various techniques of bioremediation, such as microbial remediation, phytoremediation, bio stimulation, and bioaugmentation, have shown significant success in restoring contaminated ecosystems. Microorganisms like bacteria and fungi can metabolize hazardous substances into less toxic forms, thereby reducing environmental damage. The present study highlights the causes and impacts of environmental pollution and examines the role of bioremediation as an effective solution for environmental management. It also discusses the advantages, limitations, and future prospects of bioremediation technologies. The study concludes that integrating biological remediation methods with environmental policies and public awareness can contribute significantly to pollution control and ecological sustainability.

Understanding Climate Risks in Shimla through Google Earth Engine

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This study looks at how climate change is affecting Shimla, a hill town in the Himalayas. Using Google Earth Engine and different remote sensing datasets like ERA5-Land, Landsat, MODIS, CHIRPS, and Dynamic World, we studied climate trends from 1990 to 2024. The results show that temperatures are rising and the city is expanding quickly. Snow cover is lasting for shorter periods, which shows growing stress on the local climate. Rainfall has become irregular, with heavy downpours happening more often, increasing the chances of floods and landslides. To understand these changes better, we built a Climate Vulnerability Index (CVI) that combines temperature rise, urban growth, and snow loss. We also mapped risk zones by looking at heat stress, steep slopes, and built-up areas. Population exposure analysis shows which communities are most at risk. Overall, the findings show that rising temperatures, fast urbanization, and changing rainfall are making Shimla more vulnerable. The study suggests that sustainable planning, better drainage, and climate-resilient infrastructure are urgently needed to protect the city and its people.

Keywords: Climate Change, Vulnerability Studies, Remote Sensing Tools, Google Earth Engine Applications, Rainfall Variability, Snow Cover Change

पर्यावरण प्रदूषण और जैव-उपचार: पर्यावरण संरक्षण की एक सतत एवं प्रभावी तकनीक एक अध्ययन।

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वर्तमान समय में पर्यावरण प्रदूषण विश्व स्तर पर एक गंभीर समस्या बन चुका है। औद्योगीकरण, शहरीकरण, रासायनिक पदार्थों का अत्यधिक उपयोग, प्लास्टिक कचरा, कृषि में कीटनाशकों एवं उर्वरकों का बढ़ता प्रयोग तथा प्राकृतिक संसाधनों का अनियंत्रित दोहन पर्यावरण को निरंतर प्रदूषित कर रहा है। वायु, जल और मृदा प्रदूषण के कारण मानव स्वास्थ्य, जैव विविधता तथा पारिस्थितिक तंत्र पर नकारात्मक प्रभाव पड़ रहा है। ऐसी स्थिति में जैव-उपचार पर्यावरण संरक्षण की एक प्रभावी, किफायती तथा पर्यावरण- अनुकूल तकनीक के रूप में उभर कर सामने आया है। यह अध्ययन पर्यावरण प्रदूषण को नियंत्रित करने में जैव-उपचार की भूमिका, उपयोगिता तथा प्रभावशीलता का विश्लेषण करने का प्रयास करता है। जैव-उपचार वह प्रक्रिया है जिसमें सूक्ष्मजीवों, बैक्टीरिया, फफूंद, शैवाल तथा पौधों की सहायता से प्रदूषकों को कम या समाप्त किया जाता है। यह तकनीक प्रदूषित जल, मृदा तथा औद्योगिक अपशिष्टों के उपचार में महत्वपूर्ण भूमिका निभाती है। अध्ययन का मुख्य उद्देश्य पर्यावरण प्रदूषण की समस्या को समझना तथा जैव-उपचार तकनीक के माध्यम से उसके समाधान की संभावनाओं का मूल्यांकन करना है। इस शोध में द्वितीयक डेटा का उपयोग किया गया है। अध्ययन हेतु विभिन्न शोध पत्रों, पुस्तकों, सरकारी रिपोर्टों, राष्ट्रीय एवं अंतरराष्ट्रीय जर्नल्स, पर्यावरणीय संस्थाओं की रिपोर्टों तथा ऑनलाइन स्रोतों से जानकारी एकत्रित की गई है। अध्ययन की प्रकृति वर्णनात्मक एवं विश्लेषणात्मक है। डेटा विश्लेषण के लिए विषयवस्तु विश्लेषण पद्धति का प्रयोग किया गया है, जिसके माध्यम से विभिन्न स्रोतों में उपलब्ध तथ्यों, सिद्धांतों तथा शोध निष्कर्षों का विश्लेषण किया गया। अध्ययन के निष्कर्षों से स्पष्ट होता है कि जैव-उपचार पर्यावरण प्रदूषण को कम करने की एक प्रभावी एवं टिकाऊ तकनीक है। यह न केवल प्रदूषकों को प्राकृतिक रूप से नियंत्रित करने में सहायक है, बल्कि पर्यावरणीय संतुलन बनाए रखने और सतत विकास को बढ़ावा देने में भी महत्वपूर्ण भूमिका निभाती है। शोध में यह भी पाया गया कि यदि जैव-उपचार तकनीकों का व्यापक स्तर पर उपयोग किया जाए, तो प्रदूषण नियंत्रण की दिशा में सकारात्मक परिणाम प्राप्त किए जा सकते हैं। अतः पर्यावरण संरक्षण हेतु जैव- उपचार तकनीकों के प्रति जागरूकता बढ़ाना तथा इनके प्रयोग को प्रोत्साहित करना आवश्यक है।

मुख्य शब्द : पर्यावरण प्रदूषण, जैव-उपचार, सतत विकास, पर्यावरण संरक्षण, जैव प्रौद्योगिकी। ग को प्रोत्सावहर् करना आवश्यक है।

Land Use and Land Cover Mapping of Delhi Using ESA World Cover 2020 and Google Earth Engine

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Land Use and Land Cover (LULC) mapping plays a crucial role in understanding urban expansion and environmental change, especially in rapidly growing metropolitan regions like Delhi. This study presents a geospatial analysis of LULC patterns in Delhi using the European Space Agency (ESA) World Cover 2020 dataset within the Google Earth Engine (GEE) environment. The objective is to classify and visualize land cover categories and assess the spatial distribution of key classes such as built-up areas, vegetation, cropland, and water bodies. A cloud-based geospatial workflow was implemented using JavaScript in GEE. The administrative boundary of Delhi was extracted from the FAO GAUL dataset and used to clip the ESA World Cover image. The dataset, with a spatial resolution of 10 meters, provides detailed global land cover classification. Eight major LULC classes were shown, including tree cover, shrub land, grassland, cropland, built-up areas, bare land, snow/ice, and water bodies. The results indicate a dominance of built-up areas, reflecting intense urbanization. Vegetation and cropland are limited and fragmented, while water bodies are sparse and primarily associated with the Yamuna River. The study demonstrates the effectiveness of GEE in handling large geospatial datasets and producing rapid LULC assessments. The findings can support urban planning, environmental monitoring, and sustainable land management strategies in Delhi.

Physico-Chemical and Heavy Metal Assessment of Leachate from an Open Dumping Site

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Open dumping of municipal solid waste generates leachate enriched with organic pollutants, dissolved solids, nutrients, and toxic heavy metals, posing significant environmental risks to surrounding ecosystems. The present study evaluated the Physico-chemical characteristics and heavy metal contamination of landfill leachate collected from an open dumping site in Mandi, Himachal Pradesh. Leachate samples were collected from the waste heap and peripheral regions of the dumping site and analyzed using standard APHA methods for pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), chloride, ammoniacal nitrogen, and selected heavy metals. The analytical results indicated comparatively higher pollutant concentrations in the heap leachate sample, reflecting active waste degradation and enhanced contaminant accumulation within the dumping zone. Elevated levels of COD, BOD, TDS, chloride, and TSS demonstrated substantial organic and inorganic pollution loads. Heavy metal analysis revealed significant concentrations of iron, copper, lead, and zinc, indicating the possible contribution of mixed municipal and hazardous waste fractions. Although lower concentrations were observed in the peripheral leachate sample, the detection of contaminants suggested potential lateral migration of leachate from the primary dumping area. The study highlighted the environmental implications of uncontrolled landfill leachate discharge, particularly the potential risk of soil and groundwater contamination. The findings emphasize the need for scientific landfill management, periodic environmental monitoring, and sustainable leachate treatment strategies to minimize long-term ecological and public health risks.

Environmental degradation and the importance of Bioremediation

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Environmental pollution has emerged as one of the most serious global challenges affecting human health, biodiversity, and ecological balance. Rapid industrialization, urbanization, deforestation, excessive use of chemicals, and improper waste disposal have led to the contamination of air, water, and soil. Pollutants such as heavy metals, pesticides, plastics, oil spills, and industrial effluents not only degrade the environment but also threaten sustainable development and the quality of life. Conventional methods of pollution control often involve high costs and may produce secondary pollutants, making them less sustainable in the long run. Bioremediation has gained importance as an eco-friendly and cost-effective technique for the treatment and removal of environmental contaminants. It involves the use of microorganisms, plants, fungi, or enzymes to degrade, transform, or detoxify harmful pollutants into less toxic substances. Different approaches of bioremediation, including phytoremediation, microbial remediation, and mycoremediation, have shown significant success in restoring polluted ecosystems. This method is particularly effective in treating oil-contaminated soils, industrial wastewater, agricultural pollutants, and heavy metal contamination.

Heavy metal contamination in medicinal plants: a comparative analysis of urban and rural areas of Himachal Pradesh

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Medicinal plants have long served as a primary source of healthcare. However, increasing industrialization, vehicular emissions and agricultural practices have contributed to alarming levels of heavy metal contamination in commonly used herbal plants. Despite widespread use, medicinal plants in India are not routinely monitored for such contamination, which raises safety concerns. Therefore, a study was conducted to estimate heavy metal accumulation in five commonly used medicinal plants in Himachal Pradesh, viz., *Catharanthus roseus*, *Vitex negundo*, *Justicia adhatoda*, *Murraya koenigii*, and *Achyranthes aspera*. Plant samples for each species were collected from urban and rural sites of Hamirpur district. To determine the presence of potential heavy metals, including nickel (Ni), cadmium (Cd), chromium (Cr), lead (Pb), & arsenic (As), samples were processed, digested, and further analyzed using Inductively Coupled Plasma Optical Emission Spectroscopy. The observed quantity of heavy metals followed a trend: *Achyranthes aspera* > *Catharanthus roseus*> *Justicia adhatoda*> *Murraya koenigii*> *Vitex negundo*, revealing species-specific uptake capacities. Roadside plants consistently exhibited higher metal accumulation than those far from it, especially Ni and Cr. The results were further compared with the WHO permissible limits for heavy metals in medicinal plants, which reveal that all samples exceeded the permissible safe limits of Ni and Cr. While a moderate level of Cd was observed beyond safe limits in several samples. However, Pb remained within permissible limits, while as was observed below the detectable range. The findings emphasize the urgent need for regular monitoring, quality control, and proper site selection for medicinal plant collection to ensure their safety, efficacy, and suitability for human consumption.

Assessing Spatiotemporal Patterns of Air Quality and Total Carbon from MEERA-2 Reanalysis

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Air pollution and carbon emissions are among the major environmental challenges affecting climate, ecosystems, and human health. The present study assesses the spatiotemporal patterns of air quality and total carbon using Modern-Era Retrospective Analysis for Research and Applications Version 2 (MERRA-2) reanalysis data. The study focuses on understanding the variability and distribution of atmospheric pollutants and carbon concentrations over different temporal and spatial scales. MERRA-2 datasets provide continuous long-term atmospheric observations, making them suitable for monitoring regional and seasonal environmental changes. The analysis was conducted using satellite-derived and assimilated atmospheric parameters, including particulate matter and total carbon concentrations, to evaluate trends in air quality. Spatial mapping techniques and temporal trend analyses were employed to identify variations across different regions and seasons. The results indicate significant seasonal fluctuations in pollutant and carbon concentrations, with higher values observed during winter months due to increased biomass burning, and unfavorable meteorological conditions. In contrast, lower concentrations were recorded during the monsoon season because of wet deposition and enhanced atmospheric dispersion. Overall, the findings contribute to a better understanding of air quality dynamics and carbon distribution patterns, which are essential for climate change mitigation strategies, environmental management, and sustainable policy development. The integration of reanalysis datasets with geospatial analysis offers a valuable approach for assessing atmospheric pollution and supporting future environmental research.

Keywords: Air Quality, MERRA-2, Total Carbon, PM2.5

From Materials to Reactors: Scalable Photocatalytic Strategies for Industrial Wastewater Purification

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The increasing challenges of environmental pollution, climate change, and water scarcity necessitate the development of sustainable and efficient treatment technologies. Our work focuses on the integration of photocatalysis and plasma engineering for advanced wastewater treatment, with particular emphasis on industrial effluents. Photocatalysis, inspired by natural photosynthesis, offers a promising route for pollutant degradation under light irradiation; however, its efficiency is often limited by rapid charge recombination, narrow light absorption, and inefficient charge transfer. To address these limitations, this study explores the design and engineering of two-dimensional materials and their surface modification using plasma-based techniques, enabling enhanced catalytic performance and improved solar utilization. A key aspect of this work involves the development of innovative reactor systems, including optical fiber-based reactors, double-wall reactors, and scalable continuous-flow setups. Plasma-assisted coating methods are employed to fabricate functional photocatalytic materials such as carbon nitride and Fe_3O_4-based composites on various substrates, including stainless steel, cellulose fibers, and polymer supports. These engineered systems demonstrate efficient degradation of organic contaminants in real industrial wastewater, supported by detailed mechanistic investigations. The integration of complementary processes such as electrocoagulation, nanofiltration, and photocatalysis in a pilot-scale demonstrator (200 L h^{-1}) highlights the practical applicability of the approach. Overall, this study presents a comprehensive approach that bridges material design, plasma engineering, and reactor development, offering a scalable and sustainable solution for wastewater and environmental remediation.

Synthesis and Experimental Investigation of g-C_3N_4/rGO/Ferrite Ternary Nanocomposite for Photocatalytic Degradation of Methylene Blue Dye

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In the present work, a g-C_3N_4/rGO/ferrite ternary nanocomposite was synthesized through a hydrothermal approach and experimentally investigated for the photocatalytic degradation of methylene blue. A ternary nanocomposite was developed to combine the unique properties of three different materials within a single system to study the photocatalytic performance through synergistic interaction. Ferrite nanoparticles exhibit strong visible light response and magnetic properties, enhancing photocatalytic activity. However, their efficiency is limited by rapid electron – hole recombination. To overcome this limitation, reduced graphene oxide (rGO) was introduced due to its high electrical conductivity and large surface area, which enhance electron transport and suppress charge recombination. Furthermore, graphitic carbon nitride (g-C_3N_4), a metal-free semiconductor with suitable band gap energy and excellent visible-light absorption capability, was incorporated to improve charge separation and reactive oxygen species generation. The structural, morphological, optical, and magnetic properties of the synthesized nanocomposite were investigated using various characterization techniques, including X-ray diffraction (XRD), UV–Visible spectroscopy, Fourier transform infrared spectroscopy (FTIR), and vibrating sample magnetometry (VSM). The synergistic interaction among ferrite, rGO, and g-C_3N_4 demonstrate strong potential for environmentally friendly wastewater treatment applications.

Effect of varying Fe_3O_4@PANI on physicochemical properties of graphitic carbon nitride

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In the present work, the effect of varying Fe_3O_4@PANI content on the physicochemical properties of graphitic carbon nitride was systematically investigated. The Fe_3O_4@PANI/g-C_3N_4 composites were synthesized with different concentrations of Fe_3O_4@PANI to examine the structural, optical, and chemical modifications induced in the host matrix. The synthesized samples were characterized using UV–Visible spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, and X-ray Diffraction (XRD) analysis. UV–Visible studies revealed enhanced visible-light absorption and a gradual shift in the absorption edge with increasing Fe_3O_4@PANI concentration, indicating modification in the optical band structure of g-C_3N_4. FTIR spectra confirmed the successful incorporation of Fe_3O_4@PANI into the g-C_3N_4 framework through characteristic vibrational bands corresponding to triazine units, Fe–O bonds, and polyaniline functional groups. XRD patterns demonstrated the preservation of the graphitic structure of g-C_3N_4 along with the appearance of diffraction peaks associated with crystalline Fe_3O_4, confirming composite formation. Variations in peak intensity and crystallinity suggested strong interfacial interaction between the constituent materials. The study indicates that controlled variation of Fe_3O_4@PANI significantly influences the physicochemical properties of g-C_3N_4, leading to improved optical absorption and structural modification. These findings suggest that Fe_3O_4@PANI/g-C_3N_4 composites possess potential for applications in photocatalysis, energy conversion, and environmental remediation.

Temporal variation in physicochemical characteristics of Ravi River, Chamba, Himachal Pradesh

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The present study was carried out to understand the temporal variation in physicochemical properties of the Ravi River water. Weekly water samples were collected from the Ravi River in the Chamba district of Himachal Pradesh from August 2025 to April 2026. Physicochemical characteristics of water such as pH, electrical conductivity (EC), total dissolved solids (TDS) and salinity of the water samples were measured using a multiparameter probe. The pH values ranged from a minimum of 6.7 recorded for the month of December 2025 to a maximum observed value of 7.6 for the month of April 2026. Electrical conductivity exhibited highest value of 280 µS/cm during January 2026 and lowest value of 169 µS/cm in April 2026. Similarly, TDS value was found to be vary from 196 ppm in January 2026 to 118 ppm by April 2026. Salinity of samples varied between 0.08 ppt and 0.14 ppt throughout the study period. The observed temporal variation in the measured parameters appears to be controlled primarily by the seasonal contribution from rainwater runoff and glacial meltwater in this Himalayan River along with secondary contributions. The studied parameters are found be within permissible limits as per BIS and WHO drinking water standards.

Physicochemical characteristics of Gaj Khad, Kangra, Himachal Pradesh

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The objective of this study is to study the temporal variations in physicochemical characteristics i.e., pH, Electrical Conductivity (EC), Total dissolved solids (TDS), Salinity) of the Gaj Khad water. A total of 34 samples were collected from Gaj khad during the period from 25 September 2025 to 18 April 2026 at Jangal Reserve Banoi, Kangra, Himachal Pradesh. The collected water samples were analyzed using a potable multiparameter probe. The measured pH values fluctuated from a minimum value of 6.7 for 28 January 2026 to a maximum of 7.5 for 4 October 2025 (avg 7.2). The lowest EC value of 194.33 µS, TDS value of 135.61 ppm was recorded for20 December 2025, while the highest value of EC (229.12 µS) and TDS (161.2 ppm) was recorded for 25 January 2026. The Salinity ranged from 0.09 to 0.11 ppt, showed variation in accordance with the EC and TDS. The observed fluctuations in measured physicochemical parameters i.e., pH, EC, TDS and salinity across different periods can be attributed to the varying effect of rainwater and melt water input and anthropogenic activity in the catchment. It was found that the obtained values for water quality remains within the acceptable standards prescribed by BIS.

Keyword: Physicochemical parameters, Water quality, Gaj Khad.

Physicochemical characteristics of groundwater of Manjgram gram panchayat, Kangra, Himachal Pradesh

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The present study investigates the spatial and temporal variations in physicochemical parameters of groundwater in the five villages (Dadroli, Dramman, Manjgram, Nadghuni, and Uparla Bhaniyar) of Manjgram gram panchayat in Kangra district. A total of 105 samples, 21 samples from each village, were collected from borewells with a gap of 7-10 days from September 2025 to April 2026. The physicochemical parameters such as pH, electrical conductivity (EC), total dissolved salts (TDS) and salinity were tested using a potable multiparameter probe. The data shows the maximum and minimum value of pH were recorded at Manjgram during October (7.6) and at Dadroli during February (6.6). For TDS and EC, the minimum value was recorded at Dadroli i.e., 151 ppm and 213 µS, respectively during April and maximum value was recorded at Manjgram i.e., 535 ppm and 754 µS, respectively, during November. The lowest (0.11 ppt) and highest (0.38 ppt) value for salinity was recorded at Dadroli during March & April and at Manjgram during November, respectively. On an average, Dadroli village and Manjgram village showed the minimum and maximum values of physicochemical parameters. The observed variations measured may have been influenced by the rainfall percolation, local variation in sub-surface geology and anthropogenic activities. All the studied samples fall under safe water category for human consumption as per BIS standard.

Keyword: Physicochemical parameters, groundwater, village, Manjgram

Physicochemical Characteristics of Manuni Khad, Kangra, Himachal Pradesh

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The present study was conducted to examine the temporal variation in physicochemical characteristics, i.e., pH, Electrical conductivity (EC), total dissolved solids (TDS) and salinity of Manuni Khad water in Kangra district of Himachal Pradesh. The water samples were collected from September 2025 to April 2026. The collected water samples were analyzed for their physicochemical parameters by using a portable multiparameter probe. The result shows that pH of water is found to be minimum (6.5) during January and March 2026 and maximum (7.8) during October 2025. The maximum value of EC, TDS and salinity was found to be 221µS, 157 ppm and 0.11 ppt, respectively, after a rain event in January 2026 and the minimum values was found to be 145µs, 102 ppm and 0.08 ppt, respectively, during the month of September 2025. The average values of EC, TDS, and salinity are found to be maximum (211.48 µS, 149.59 ppm and 0.10 ppt) for April 2026, while the minimum values were observed for October month (149.10 µS, 104.58 ppm and 0.08 ppt). The observed temporal variation in physicochemical parameters shows the influence of variable rainfall, glacial melting, rock water interaction and anthropogenic activity in the catchment. The results shows that Manuni Khad water is found to be suitable for the drinking purpose as per BIS.

Keywords: Water resources, Physicochemical parameters, Water quality, Manuni Khad, Kangra.

Studies on the effect of planting dates and nutritional modules on the performance of 'Bidhan Marigold-2"

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The present investigation was carried out at the experimental farm of Department of Floriculture and Landscaping, Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during 2024 under open field conditions. The experiment comprised of five planting dates viz., March 15, April 15, May 15, June 15 and July 15 and nutritional modules i.e. T_1 (RDF 100 %), T_2 (RDF 100 % + Intercrop), T_3 (Jeevamrit 20 %) and T_4 (Jeevamrit 20 % + Intercrop). From the present investigation it has been revealed that parameters like plant spread (60.06 cm), number of primary branches (14.68), size of flower (6.73 cm), weight of single flower (10.51 g), shelf life (5.51 days), viable microbial count viz., bacterial, fungal and actinomycetes (10.88 x 10^6 cfu/g, 4.35 x 10^2 cfu/g and 6.37 x 10^4 cfu/g, respectively) and benefit cost ratio (1.89) were found maximum in T_4 (Jeevamrit 20 % + Intercrop) under June 15 planting. Whereas, days taken to earliest flower bud initiation (30.97 days), earliest days taken to first flowering (58.16 days), number of flowers per plant (194.05), number of flowers per square meter (1698.60), flower yield per plant (1393.18 g), duration of flowering (56.05 days), yield of French bean per plant (148.82 g) and soil organic carbon content (1.30%) were found maximum in T_4 (Jeevamrit 20 % + Intercrop) under March 15 planting. March 15 planted resulted in maximum available nitrogen in soil (356.43 kg/ha), available phosphorus in soil (65.82 kg/ha) and available potassium in soil (358.24 kg/ha) under T_2 (RDF 100 % + Intercrop). However, plant height (125.02 cm) was found maximum in T_2 (RDF 100 % + Intercrop) when planted on June 15. Further, with help of planting dates flowering can be regulated from May 12 to November 18.

Maleic acid-esterified alginic acid hydrogel with advanced binder properties for energy storage applications

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With the increasing demand for sustainable and high-performance materials for energy storage devices such as supercapacitors and batteries, polymer-based binders play an important role in holding the electrode components together. This study focuses on the extraction of alginic acid from sodium alginate using HCl to form a hydrogel network. The conversion of sodium alginate into alginic acid was analyzed using Fourier-transform infrared (FTIR) spectroscopy. Subsequently, alginic acid was chemically crosslinked with maleic acid, which was obtained through the hydrolysis of maleic anhydride, resulting in the formation of a 3D network structure. The crosslinking was analyzed by observing the shifts in absorption peaks using Fourier-transform infrared (FTIR) spectroscopy. Maleic acid-esterified alginic acid offered excellent film-forming ability and controlled swelling properties, which promoted better ion exchange and enhanced electrolyte-electrode interactions in energy storage devices. The modified alginic acid binder was further utilized in the fabrication of a composite anode consisting of silicon and graphite. This composite enabled the successful formation of a stable and efficient electrode. The three-dimensional crosslinked network of alginic acid accommodated structural changes caused by silicon volume expansion. Overall, maleic acid-esterified alginic acid significantly improved adhesion, thermal stability and mechanical properties. This modification demonstrates promising potential to replace the need for conventional synthetic binders for energy storage devices.

Hydrothermal synthesis of $NaTaO_3$ and its effective photocatalytic performance for degradation of organic pollutants

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$NaTaO_3$ have been successfully synthesized by hydrothermal method and Rhodamine B (RhB) was used as a model dye to evaluate their photocatalytic efficiency under UV-light irradiation. The $NaTaO_3$ samples were characterized by various techniques, such as X-ray diffraction (XRD), ultraviolet visible (UV-Vis). The XRD and UV-Vis results confirmed the synthesis of $NaTaO_3$. The XRD pattern confirmed the formation of pure nanoparticles with monoclinic structure of 30.12 nm of crystallite size. The UV-Vis spectroscopy shows maximum absorbance with the band gap of 3.96 eV. In photocatalytic degradation experiment, $NaTaO_3$ presented the photocatalytic degradation of 91.42% of RhB after 330 min of reaction. The present study demonstrated that $NaTaO_3$ is a efficient photocatalysts for dye degradation and hold promise as cost-effective and environmentally friendly materials for wastewater treatment.

Keywords: Hydrothermal, Rhodamine B, Monoclinic, Crystallite, Photocatalytic

Sustainable Gd_2O_3-ZnO Nanocomposites for Enhanced Photocatalytic Environmental Remediation

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Gadolinium oxide-Zinc oxide (Gd_2O_3-ZnO) nanocomposites were synthesized and investigated for their photocatalytic degradation of Rhodamine B dye under light irradiation. In this study, Gd_2O_3-ZnO nanocomposites were synthesized via a solution combustion method using tartaric acid as fuel at 600°C. Comprehensive characterization techniques, including X-ray diffraction (XRD), field-emission scanning electron microscopy (FESEM), ultraviolet-visible (UV-Vis) spectroscopy, Fourier-transform infrared (FTIR) spectroscopy and energy-dispersive X-ray spectroscopy (EDS), confirmed the successful formation of the nanocomposites. The incorporation of Gd_2O_3 into ZnO improved charge-carrier separation, resulting in superior photocatalytic activity compared to pristine ZnO. The synthesized nanocomposites exhibited efficient degradation of Rhodamine B dye, demonstrating their potential for wastewater treatment and environmental remediation. In addition, the photocatalyst showed good stability and reusability over multiple degradation cycles, highlighting its suitability as a sustainable material for green chemistry applications.

Keywords: Gd_2O_3-ZnO nanocomposites; Photocatalysis; Rhodamine B dye degradation.

Synthesis of schiff base zinc sulfide (ZnS Nps) nanoparticles and their applications

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The rise of nanotechnology leads to great interest in the formation of nanoparticles. Recently imine –capped ZnS nanoparticles were greatly interested because ZnS can act as non-toxic semiconductor. Therefore, present study focuses on the formation of ZnS nanoparticles using the imine compound as a capping agent. At first ,the imine compounds was synthesized using 4 –hydroxy acetophenone (1-(4-Hydroxyphenyl)ethan-1-one)and 4-bromoaniline (p-Bromo phenylamine).The structure of the compound was confirmed using nuclear magnetic resonance (carbon and proton)spectroscopy ,Fourier transform infrared spectroscopy(FT-IR) and UV –visible spectroscopy .Further imine –based ZnS NPs were synthesized using the co-precipitations method and their structure was characterized by X ray diffraction (XRD), Fourier transform infrared spectroscopy(FT-IR) after that ,these particles were used to degrade sunset yellow dye under UV light and different parameters were used to test degradation parameters including the effect of constant time ,adsorbent dosage and pH dose .The best degradations time was 75 minutes with 20mg adsorbent dose and basic pH –14 .About 70% of the dye was degraded .

Fabrication and Multidimensional Physicochemical Characterization of a Biowaste-Derived Inorganic–Carbonaceous Hybrid Nanocomposite

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The rise in global demands for sustainable agriculture has prompted the development of biocompatible functional materials using eco-compatible bio-waste feedstocks, which can effectively tackle the issues related to soil degradation and decrease in physicochemical quality of soils. In this study, a systematic approach is taken to design, formulate, and characterize a novel inorganic-carbonaceous nanocomposite synthesized from two different biowaste sources. One acts as an inorganic source material with structural rigidity, surface alkalinity, and reactivity associated with its mineral composition. The other source acts as the carbonaceous component in the composites offering a highly porous, high surface area scaffolding structure, which allows stabilization and functionalization of the inorganic phases. This study seeks to demonstrate the synergy created through the interaction of both the components and resulting in superior characteristics than those achieved by either individually. Key elements include optimization of the conditions required for preparation of nanocomposite through control of precursor ratio, processing, heat treatments, and surface modifications allowing precise manipulation of crystallography of composite phases, nanoparticle size distribution, morphology uniformity, porosity, and surface functional groups density. Characterizations are performed using a variety of diffraction, spectroscopy, microscopy, and thermogravimetry methods to provide full insights on their structure, phase interaction, and surface chemistry. The novelty of the work is in the formulation science of the synthesis of novel nanocomposites through sustainable approaches.

Keywords: nanocomposite, biowaste-derived, green synthesis, hybrid nanoarchitecture, sustainable materials.

Fabrication of CoNi-MOF Electrode Material for Electrochemical Sensing of Lead Nitrate

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This study presents a sustainable and economical approach for the selective electrochemical detection of Pb^{2+} ions using a bimetallic cobalt–nickel metal–organic framework (CoNi-MOF) modified electrode. The synthesized CoNi-MOF was used to modify a glassy carbon electrode (GCE) for enhanced sensing performance. Electrochemical studies were performed using cyclic voltammetry (CV) to compare the electrochemical behavior of bare GCE and modified CoNi-MOF/GCE, where the modified electrode exhibited improved current response and faster electron transfer. Differential pulse anodic stripping voltammetry (DPASV) was employed for concentration-dependent analysis of Pb^{2+} ions and for the calculation of the limit of detection (LOD). The developed sensor demonstrated high sensitivity, rapid response, excellent selectivity, and good stability for Pb^{2+} ion detection. Furthermore, selectivity studies confirmed effective sensing performance even in the presence of interfering metal ions. The obtained results suggest that the CoNi-MOF modified electrode is a promising material for efficient environmental monitoring of lead contamination.

Keywords: Electrochemical Sensing, Metal–Organic Frameworks, Lead Ion Detection**,** Heavy Metal Contamination**,** Bimetallic Nanomaterials

Solid State Synthesis of $La_{0.7}(Ca/Sr)_{0.3}MnO_3$ for Energy Storage Applications

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Perovskite materials $A_{1-x}B_xMnO_3$ (A = trivalent rare earth ions, B = divalent alkaline earth ions) have potential applications in many fields, for instance; fuel cells, sensors, magnetic refrigeration, spintronics, infrared devices, and colossal magneto-resistance etc. $La_{1-x}A_xMnO_3$ are also widely used in storage devices because of occurrence of phase transitions. The present study reports on the synthesis of $La_{0.7}(Ca/Sr)_{0.3}MnO_3$ via standard solid state reaction route. The synthesised of $La_{0.7}(Ca/Sr)_{0.3}MnO_3$ material was done by taking high purity (Sigma Aldrich 99.99%) of fine powders weighted in required stoichiometric proportion, lanthanum oxide (La_2O_3), manganese oxide (MnO_2), strontium carbonate ($SrCO_3$), calcium oxide (CaO). The calcination of these powders was done at 850 ˚C for 24 hrs, reground and pressed the powder under 15 MPa pressure (form pallet). Now, sintering the pallets at 1050 ˚C for 24 hrs, repeat the sintering process again and final sintering was done at 1250 ˚C for 24 hrs (slow cooling 3 ˚C/min). The synthesized material having significant role in solid oxide fuel cell technology like solid oxide fuel cell machineries, mostly based on advanced materials, hold pronounced capacity for a sustainable energy future prospect. With current research addressing the material encounters-ranging from refining catalyst efficiency to emerging new electrolytes and talking robustness issues. A sustained innovation in the oxide materials used for fuel cells is crucial for overcoming current limitations and accelerating the adoption of fuel cell technology across various sectors, from transportation to stationary power generation. We will hopefully be able to deal with such limitations.

Keywords: Solid oxide fuel cells, solid state reaction synthesis, environmental impact, energy storage materials etc.

The Synthesis of Oxalic Acid-crosslinked Guar Gum hydrogel as an eco-friendly binder material for anode fabrication

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Natural polysaccharide-based hydrogels are emerging as sustainable, biocompatible adhesives with tunable mechanical properties and high-water content. This work reports the synthesis and characterization of a chemically crosslinked guar gum (GG) hydrogel using oxalic acid as a crosslinking agent, enhancing its adhesive property and evaluated for its potential as an anode binder material. Guar gum was crosslinked with 2 wt% oxalic acid *via* solution mixing followed by acetone precipitation and thermal curing at 110°C for 15 minutes, forming a three-dimensional network via ester bond formation between the primary hydroxyl groups of Guar Gum and the carboxyl groups of oxalic acid. The crosslinked guar gum hydrogel was characterized using Scanning electron microscopy (SEM), Thermogravimetric analysis (TGA), Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD) and Zeta potential. The resultant hydrogel was tested for swelling percentage and solubility. A swelling percentage of 866% was recorded, indicating a highly hydrophilic and porous network structure. Although the crosslinking reaction causes a light color variation making the sample assume a brownish shade. FTIR spectroscopic analysis confirmed successful crosslinking between guar gum and oxalic acid, as evidenced by broadening of the O–H stretching band at 3400 cm^{-1} and characteristic modifications in the carbonyl region 1730 cm^{-1}. The crosslinked GG hydrogel was subsequently assessed as a binder for anode preparation, targeting improved electrode integrity and interfacial stability.

Development of a humidity-tolerant room-temperature ammonia sensor based on PANI/ZnO/$Ti_3C_2T_x$ MXene ternary nanocomposites

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Ammonia monitoring is a key requirement in the industrial, environmental and biomedical facilities, as ammonia is a toxic chemical and a major source of secondary aerosols such as ammonium nitrate. Traditional metal oxide sensors have been shown to exhibit stability, but are often limited by high operating temperatures (> 200°C), compared to conducting polymers like polyaniline, which have problems with humidity effects and stability. To address these challenges, this study proposes the development of a humidity-tolerant, room-temperature ammonia sensor based on a PANI/ZnO/$Ti_3C_2T_x$ MXene ternary nanocomposite. The synthesis involves a hydrothermal process followed by in situ polymerization of aniline in the presence of ZnO nanoparticles and $Ti_3C_2T_x$ MXene to form a hybrid structure. The morphology, crystal structure and chemical composition of the prepared sample are tested by various characterization method. The sensing principle is expected to combine the synergistic characteristics of n-p-n heterojunction and high metallic conductivity of MXene, catalytic nature of ZnO and reversible redox capability of PANI. The sensor is expected to have a high sensitivity, selectivity and response/recovery kinetics. This study presents a strong foundation for high-performance ammonia sensing and has a high potential in environmental monitoring systems and health tracking devices.

Development of Oxalic Acid Crosslinked Chitosan as an environmentally benign binder for electrode preparation

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Hydrogel, a hydrophilic 3D network that can store large amounts of water and biological fluids. Natural polymers hydrogels have become popular in various fields like biomedical and environmental remediation, due to their biocompatibility and biodegradability. Chitosan is a deacetylated derivative of chitin, containing amino (C2) and hydroxyl (C3, C6) functional groups, which contribute to its useful properties and applications. Its less solubility in neutral and basic mediums hinders its application in various fields. In this study, chitosan (C) was crosslinked with oxalic acid which is used as a crosslinker by 36wt%, where the ionic interactions occur between the protonated amino groups ($–NH_3^+$) of chitosan and carboxylate groups ($–COO^-$) of oxalic acid resulting in an amorphous polymer network, followed by acetone precipitation and thermal curing at 110°C for 15 minutes. The crosslinking shows the visible changes from white flakes to a light yellowish powder. The characterisation was done by X-ray Diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, Scanning electron microscope (SEM), Thermogravimetric analysis (TGA) and Zeta Potential. The solubility test was also conducted. The results revealed a swelling ratio of 300% after 24hr, its FTIR peak between 1400-1700cm^{-1} shows the crosslinking between oxalic acid and chitosan. The modified chitosan with oxalic acid can be used as a binder for potential applications in the electrode preparation.

Efficient removal of crystal violet dye using $MgTiO_3$ nano photocatalyst prepared by sol–gel auto-combustion method

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Magnesium titanate ($MgTiO_3$) nanoparticles were effectively synthesized utilizing an enhanced sol–gel auto-combustion methodology. The resultant material was subjected to characterization through X-ray diffraction (XRD), Energy Dispersive Spectroscopy (EDS), and UV–Visible spectroscopy to examine its structural, elemental, and optical characteristics. XRD analysis validated the emergence of a crystalline $MgTiO_3$ phase, exhibiting an average crystallite dimension of 32.38 nm, whereas EDS analysis indicated the existence of magnesium, titanium, and oxygen as the primary constituent elements. The optical band gap energies, derived from Tauc plot analysis, were determined to lie within the range of 2.69–2.86 eV. The photocatalytic performance of the synthesized $MgTiO_3$ nanoparticles was assessed concerning the degradation of crystal violet dye when subjected to visible light irradiation. The material demonstrated a notable degradation efficiency of approximately 97–98% under optimized conditions, thereby underscoring its potential applicability as a highly effective visible-light photocatalyst for wastewater treatment and environmental remediation.

Keywords: $MgTiO_3$, Photocatalysis, Crystal violet, Sol-gel synthesis, Nanoparticles, Wastewater treatment.

Eco-Friendly Starch–Oxalic Acid Hydrogel: A Potential Binder Material

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Hydrogels are 3D hydrophilic networks with high water absorption capacity. They are categorised as synthetic or natural in origin. Starch-based hydrogels are sustainable, biodegradable, and cost-effective materials. This research focuses on the synthesis and characterisation of starch-based hydrogel, by utilising crosslinking method with oxalic acid as a crosslinking agent, to improve its structural stability and performance as an electrode material. During synthesis, starch was crosslinked with 20 wt% oxalic acid via solution mixing followed by acetone precipitation and thermal curing at 115°C for 20 minutes, and this resulted in formation of 3D network. The as-synthesised starch-based hydrogel was analysed by using different characterisation techniques such as, Scanning Electron Microscopy (SEM), and FTIR. Then the hydrogel was tested for the swelling percentage and solubility. The swelling percentage was measured to be about 130%, and this indicated good water absorption and network formation. Even slight colour change was also observed, i.e. from pure white to off white. FTIR analysis shows broadening of the O-H stretching band at 3200–3500 cm^{-1} with some peaks at 2900 cm^{-1} corresponding to C-H stretching, while between 1000–1150 cm^{-1} corresponds to C-O-C vibrations, and C=O stretching at 1700–1750 cm^{-1} confirmed successful modification of the hydrogel. The as-synthesised starch-based hydrogel shows enhanced mechanical strength, adhesive properties, and structural stability. This makes it suitable for use as an electrode material in the advanced energy storage systems.

Recent Advances in Coating Materials and Deposition Techniques for High-Performance TiO2 Photoanodes

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Photoelectrochemical (PEC) water splitting is a promising approach for sustainable hydrogen production through direct solar energy conversion. Among various semiconductor materials, Titanium dioxide (TiO_2) photoanodes are widely studied because of their excellent chemical stability, low cost, non-toxicity and strong photo corrosion resistance. However, their practical application is limited by wide bandgap energy, low visible-light absorption and rapid charge recombination, leading to reduced photocurrent density. This review focuses on TiO_2 photoanodes based on coating materials, stability, and photocurrent performance. Various coating materials, including metal oxides, sulfides, noble metals, carbon-based materials, conductive polymers and cocatalysts are critically compared for their effects on charge separation, light absorption and PEC stability. Additionally, major fabrication techniques such as sol-gel, spin coating, hydrothermal synthesis, spray pyrolysis, and electrodeposition are evaluated in terms of film quality, scalability, stability and photocurrent enhancement for efficient PEC water splitting applications.

Occurrence and Distribution of Microplastics in the Beas River Region of Kangra District, Himachal Pradesh

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Microplastics (MPs) pollution has emerged as a pervasive contaminant in freshwater systems posing significant environmental and ecological risks. This study investigates MPs contamination in river water focusing on both upstream and downstream variations and the influence of anthropogenic and environmental factors. Samples collected from four different locations along the Beas River namely Sandhol, Jaisinghpur, Sujanpur and Dehra to assess the abundance, distribution and characteristics of MPs including size, shape and color. Preliminary results suggest that MPs concentrations are generally higher in urbanized areas, correlating positively with population density, residential land use and precipitation while being negatively associated with forested and agricultural regions. Spatial analysis revealed that upstream sites often exhibit lower MPs loads with sharp increases observed at transitions to urbanized zones, while downstream transport is influenced by hydrological management including flow diversions. These findings will highlight the complex interactions between land use and hydrodynamics in shaping MPs contamination patterns and underscore the importance of targeted management strategies to mitigate microplastics pollution in freshwater ecosystems.

Keywords: Microplastics, freshwater system, anthropogenic, hydrodynamics, contamination.

Biomass Derived Carbon Supported NiFeCo-LDH as Efficient Material for Supercapacitor Applications

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The rapid rise in global population and technological advancements has increased the global energy demand. This has resulted in the quest for efficient and sustainable energy storage technologies. In this context, supercapacitors (SCs) have attained considerable attraction due to their high-power density, good energy density and rapid charge-discharge ability. But, the performance of SCs directly depends on the type of electrode material used for their fabrication. In recent years, biomass derived carbon has emerged as a promising sustainable alternative as electrode material because of their renewable nature and abundance availability. In this work, carbon derived from *Areca catechu* husk with KOH activation supported NiFeCo-LDH is studied for sustainable electrode material. The introduction of LDH in carbon matrix can modify the electronic structure and introduce additional reaction sites which enhances the overall performance of the electrode. Overall, the *Areca catechu* husk and LDH composite delivered capacitance of 1500 F/g at current density of 0.5 A/g. Therefore, such composite materials serve as sustainable, low cost and high performing material for advanced supercapacitors, while also promoting the use of agricultural waste as energy storage materials.

Keywords: Biomass, Carbon Materials, Layered Double Hydroxides, Sustainability, Areca catechu, Supercapacitor.

Supramolecular Modulation of Charge Transfer Pathways in π-Extended 2D-Azeno Nanosheets for Selective Spermine Sensing

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Biogenic amine surveillance is essential for food safety and clinical diagnostics, yet real-time selective spermine (SPM) detection remains challenging due to molecular similarity amongst amines and probe instability in complex matrices. Here, we present a reusable, wavelength-shift–responsive fluorescent probe derived from two-dimensional azene nanosheets, synthesized through a Schiff's condensation route followed by ultrasonic exfoliation. The robust, π-extended framework exhibits intense photoluminescence, capable of achieving an ultra-low detection limit via a unique fluorescence quenching response. DFT calculations will be employed to back up mechanistic interrogation, which will show that the selective sensing results from site-specific, cooperative interaction between the polyamine functional

groups of SPM and 2D-Azeno scaffold due to the supramolecular interactions modulating the charge transfer pathways rather than from traditional Inner Filter Effects. Moreover, acid fuming can protonate the amine sites, disrupting the supramolecular connections and completely regenerating the initial emission state across multiple operating cycles, rendering this sensing mechanism intrinsically reversible. This work will help in establishing a paradigm for supramolecular control over solid-state electronic structure in rigid 2D organic materials, offering a generalizable design principle for developing robust, regenerable, and high-fidelity optical sensors applicable to environmental monitoring and precision biomedicine.

Influence of Mg^{2+} Substitution on the Structural, Elastic, Magnetic Properties of $MnFe_2O_4$ nanoparticles

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In the present work, $MnFe_2O_4$ nanoparticles were synthesized to evaluate the effect of Mg^{2+} substitution on the elastic, magnetic and structural properties of $Mg_xMn_{1-x}Fe_2O_4$(x= 0.0 and 0.05). XRD analysis confirmed the formation of single-phase cubic spinel ferrite structure. The crystallite size increased from 23.05 nm to 35 nm after Mg^{2+} substitution. Slight peak shifts indicated successful incorporation of Mg ions, resulting in modified cation distribution and structural changes within the spinel framework. FTIR analysis revealed shifts in tetrahedral and octahedral bands from 616/ 576 cm^{-1} to 414/419 cm^{-1} corresponding to the spinel structure. The tetrahedral force constant (K_t) decreased from 2.76/ 2.42 dyne cm^{-1} while the octahedral force constant (K_o) increased from 125/ 128 dyne cm^{-1}, indicating redistribution of cations and modification of metal–oxygen bonding within the spinel lattice while reduced lattice energy suggested weakening of interatomic interactions after Mg doping. VSM analysis confirmed the ferrimagnetic behavior of pure and Mg doped nanoparticles. The saturation magnetization decreased from 64.82 emu/g to 49.91 emu/g after Mg^{2+} substitution, attributed to replacement of magnetic Mn^{2+} ions by nonmagnetic Mg^{2+} ions and modified A–B super exchange interactions. FESEM micrographs showed an increase in particle size after Mg^{2+} substitution, indicating modification in the crystallization behavior of the ferrite system. The overall results demonstrate that Mg^{2+} substitution effectively tailors the structural, elastic and magnetic properties of $MnFe_2O_4$ spinel ferrites.

Green recovery of graphite from spent lithium-ion battery black mass by soap-nut-assisted froth flotation

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The increasing proliferation of lithium-ion batteries (LIB) in the energy storage sector has led to a significant increase in spent-LIB waste. This necessitates efficient and sustainable recycling strategies. While most research attention has been directed towards the recovery of critical metals, graphite remains underutilized despite being highly economical and having high functional value, in addition to its considerable concentration present in LIBs. This study presents an environmentally benign approach for the recovery of graphite from spent-LIB black mass using soap-nut derived natural surfactants and froth floatation method. Process parameters including S/L ratio, conditioning time, reagent concentration, oil concentration was systematically optimized for enhancing graphite recovery. Soap-nut functioning as a biodegradable frothing agent in combination with mustard oil functioning as a collector achieved a recovery efficiency of up to 80 % under optimized conditions for graphite, eliminating the need for the use of conventionally toxic floatation reagents. This work demonstrates a green floatation route for the recovery of graphite using bio-based reagents for a sustainable LIB recycling.

Keywords: Lithium-ion batteries, Graphite flotation, Black mass recycling, Bio-based surfactant, Soap-nut extraction, Froth flotation, green recycling, Sustainable recovery

Spent Lithium-Ion Batteries: Cathode & Black Mass Characterization for Global E-Waste Recycling

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The rapid growth of electric vehicles has intensified lithium-ion battery (LIB) use, leading to escalating e-waste. Spent LIBs retain critical metals but undergo structural and chemical deterioration. This study presents a comparative evaluation of NMC, LFP, and LCO cathodes alongside black mass, employing SEM, EDS, and XRD. SEM revealed cracked LCO particles, agglomerated NMC grains, and uniform LFP morphology, while black mass exhibited carbon-rich disorder. EDS confirmed Ni-rich NMC, Fe–P–O in LFP, and Co-rich LCO, with lithium depletion across samples. XRD validated crystalline phases in cathodes but showed broadened, disordered peaks in black mass. These findings highlight degradation pathways and binder residues, offering insights into cathode stability versus black mass disorder. The work supports circular economy strategies for sustainable recovery of Ni, Co, Mn, and Fe from LIB waste.

Usage of Pectin/Collagen Biosorbent for Sustainable Agriculture

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Biowaste-derived smart hydrogels represent an emerging and eco-friendly technology with significant potential for enhancing agricultural productivity and resource efficiency. These hydrogels are synthesized from biodegradable waste materials such as agricultural residues, food waste, and biomass-based polymers including chitosan, cellulose, lignin, and starch. Their ability to absorb and retain large quantities of water, respond to environmental stimuli, and release nutrients in a controlled manner makes them valuable for addressing challenges such as soil degradation, water scarcity, and inefficient fertilizer use. Smart hydrogels improve soil moisture retention, reduce irrigation frequency, minimize nutrient leaching, and enhance seed germination and plant growth. Furthermore, their biodegradability eliminates long-term ecological risks associated with synthetic polymer hydrogels. Despite their advantages, large-scale implementation faces constraints related to production cost, material consistency, and long-term field performance under diverse climatic conditions. Ongoing research focuses on optimizing mechanical strength, responsiveness to pH and temperature fluctuations, and integration with nanomaterials to enhance nutrient delivery efficiency. Overall, biowaste-derived smart hydrogels offer a promising sustainable alternative for future climate-resilient agriculture, contributing to circular economy principles and reducing environmental footprints in farming systems.

Waste to Wealth: Sustainable Waste Management in Floriculture through Dry Flower Technology

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Floriculture generates a substantial quantity of floral waste during cultivation, harvesting, marketing, and post-consumer use, leading to environmental and disposal challenges. Sustainable waste management through dry flower technology has emerged as an effective approach for converting otherwise discarded floral materials into value-added products with economic and aesthetic significance. Dry flower technology involves the preservation and processing of flowers, foliage, pods, grasses, and other plant parts using techniques such as air drying, press drying, silica gel drying, glycerinization, and embedded drying. Floral residues and unsold flowers can be transformed into decorative and utility products including greeting cards, wall hangings, potpourri, bouquets, floral arrangements, candles, handmade paper, jewelry, and eco-friendly handicrafts. The technology offers a sustainable solution for waste reduction while promoting resource utilization, environmental conservation, and rural entrepreneurship. It also provides additional income generation opportunities for farmers, self-help groups, tribal women, and small-scale floriculture industries. Utilization of biodegradable floral waste through dry flower products supports circular economy principles and reduces dependence on synthetic decorative materials. Moreover, dry flower products possess longer shelf life, low maintenance, and growing demand in domestic and export markets. Despite its potential, challenges such as lack of technical awareness, proper storage facilities, market linkage, and skill development limit its large-scale adoption. Therefore, capacity building, technological interventions, and promotion of eco-friendly floral enterprises are essential for sustainable development of the floriculture sector. The present study emphasizes the role of dry flower technology as an innovative and sustainable waste management strategy in floriculture for environmental sustainability and livelihood enhancement.

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Activities


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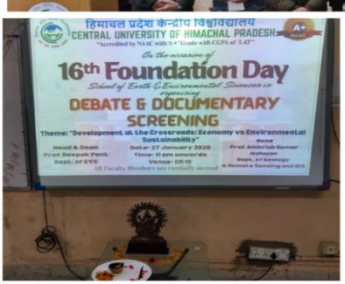

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