40th M.P. YOUNG SCIENTIST CONGRESS

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Vikram University, Ujjain (M.P.)

Abstracts

M.P. Council of Science and Technology

Vigyan Bhawan, Nehru Nagar, Bhopal (M.P.) 462003

Hosted by

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FOREWARD

Industry, academia and government are three pillars of research ecosystem responsible for building an innovation friendly India. The role of academia is to provide intellectual resources, industry including startups to utilize these resources and extend market development whereas government is responsible to formulate policies and regulations and provide risk funding and funding of a new technology. Currently there is a higher focus on publications in S&T research but the need is to strengthen translation of this research to Technology Readiness Level (TRL) 6 to 8 i.e. technology demonstration and system development level.

As the world moves fast toward an increasingly dynamic and complex future, one constant remains: the boundless potential of its youth. This resource of the youth is an important building block for transforming India into a developed nation. Science is a powerful tool that youth are readily wielding, creating safe spaces for all walks of life. While celebrating Yuva Vaigyanik Sammelan and Vigyan Utsav, we turn our attention to the future innovators – the young minds whose creativity and curiosity are reshaping the landscape of science and technology. Science runs the world; and youth are the key to ensure its continued advancement and aid in protecting this world.

The Madhya Pradesh Young Scientist Congress is being organized every year since 1986 with the objective of generating interest in research work among the meritorious young scientific talents of Madhya Pradesh and to encourage them in this direction.

The Vikramotsav comprising of Rashtriya Vaigyanik Sammelan and 40th Madhya Pradesh Yuva Vaigyanik Sammelan is being organized by the Madhya Pradesh Council of Science and Technology at Ujjain during March 27-29, 2025. The research papers in 17 S&T subjects are expected to be presented by the Yuva Vaigyanik of MP. On this occasion, meritorious young scientists will be identified and felicitated.

I am sure that under the guidance of Honourable Chief Minister of Madhya Pradesh, Dr. Mohan Yadavji, Yuva Vaigyanik of MP will attain greater heights in future to serve the society in addressing the complex socio-economic challenges through input of new and innovative technology for improving India's position in Key Innovation Indicators and shaping developed Madhya Pradesh.

I wish the Rashtriya Vaigyanik Sammelan and 40th Madhya Pradesh Yuva Vaigyanik Sammelan a grand success.

(Dr. Anil Kothari)
Director General
MPCST, Bhopal

FOREWARD

Science and innovation are the driving forces behind progress and nurturing young minds in this domain is crucial for a brighter future. The Madhya Pradesh Young Scientist Congress (MPYSC), organized annually by the Madhya Pradesh Council of Science and Technology (MPCST), Bhopal has been a beacon of encouragement for emerging researchers, offering them a stage to present novel ideas and contribute to the scientific community. As we celebrate the 40th edition of this esteemed event, Vikram University, Ujjain, is honored to be the host, reaffirming its dedication to research, knowledge and discovery.

This Young Scientist Congress serves as a vital catalyst, fostering an environment where curiosity meets rigor and ideas transform into impactful solutions. It is heartening to see young researchers from diverse disciplines come together to exchange knowledge, challenge perspectives and push the boundaries of science and technology. This year, 257 researchers will present their papers across 17 disciplines, reflecting the diversity and depth of scientific exploration taking place in our state. Their work today will shape the advancements of tomorrow, reinforcing the role of research in societal growth.

Great scientists and visionaries have always emphasized perseverance, critical thinking, and a relentless pursuit of knowledge. I encourage all participants to embrace these qualities, use this platform to its fullest and embark on a journey of scientific excellence. The challenges of today are the stepping stones to tomorrow's breakthroughs.

I extend my best wishes to all the young scientists participating in the 40th MPYSC. May this event inspire new ideas, foster meaningful collaborations and pave the way for a future rich in discovery and innovation.

Prof. Arpan Bhardwaj
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Vikram University, Ujjain

40th M.P. Young Scientist Congress

Subject Index

Effect of Ohmic Heating on Milling Quality of Parboiled Paddy

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Ohmic heating works on the principle of Ohm's law. It is a novel technology for processing of food. Many food processing works can be done through this technology such as sterilization, blanching, pasteurization, parboiling etc. Parboiling is a partial cooking of rice within the husk. It is a hydrothermal treatment. Parboiling of paddy is done in three steps, i.e. soaking, steaming, and drying. In this research an ohmic heating model was developed to parboil the paddy. Experiments were conducted for variety of MTU 1010 paddy with raw and parboiled samples. The mixture of paddy and water was taken in the ratio of 1:3. The performance of milling process is judged by total yield, head yield and broken rice percentage. and observations were taken at different voltage gradients of 24.44, 25, 25.56, 26.11 and 26.67 V/cm in the ohmic heating chamber at the time interval of 0, 5, 10, 15, 20, 25, 30, 35 and 40 min. The study was resulted that the highest head yield of 88.09% and lowest broken yield of 11.90 % with a highest milling efficiency of 74.96% for parboiled samples. Whereas, the raw sample had a head yield of 61.50 and broken of 38.56% with a milling efficiency of 73.35%. The results given a clear explanation to improvement in milling quality of parboiled paddy by ohmic heating.

Computer Vision Based Disease Detection and Precision Spraying System for Tomato Crop

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In major areas of India, Tomatoes are the main horticultural crop grown inside protected cultivation, facing the challenge of accurate disease identification. The precise spraying of disease-specific pesticides over tomato crops is a major issue for polyhouse-grown tomatoes. In order to solve this issue, efforts were made to detect the disease type accurately using a newly developed hybrid Vision Transformer (ViT) model deployed in a computer vision (CV) based embedded system. Therefore, a manually drawn precision sprayer integrated with an embedded system was developed, evaluated and compared in this study.

A dataset of diseased and healthy tomato leaves was used to train a hybrid ViT model, with optimized hyper-parameters for enhanced classification accuracy. The model was deployed in an embedded system integrated into a sprayer, tested at speeds of 0.34, 0.82, and 1.13 km h^{-1} for detection efficiency and discharge rates. Nozzle placement was optimized for site-specific pesticide application based on lag time and travel distance. Field evaluations measured pesticide application rates, field capacity, and spray effectiveness for late blight and powdery mildew. Water-sensitive paper analysis confirmed precise and efficient pesticide delivery at varying heights (0.3, 0.75, and 1.2 m) and for different pesticides (Metalaxyl 8% + Mancozeb 64% WP and Sulfex 80% WP).

The developed system achieved 95.83% detection efficiency for diseased plants at 0.34 km h^{-1}, with an optimized sensor-to-nozzle distance of 701 mm. Precision spraying reduced pesticide application rates to 355.66 L ha^{-1} for late blight and 257.72 L ha^{-1} for powdery mildew, compared to 902.04 L ha^{-1} in conventional spraying. The system minimizes pesticide overuse, environmental impact, and labor, offering a sustainable solution for tomato growers. This research advances precision agriculture and highlights the potential of hybrid deep-learning models in enhancing crop management and productivity.

Development, Characterization and Application of a Natural Anthocyanin-Based Colorimetric Freshness Indicator for Sustainable Food Packaging Solutions

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This study aimed to design and evaluate a pH-sensitive colorimetric freshness indicator for real-time monitoring of perishable foods. The indicator incorporated black carrot anthocyanins, a natural, food-grade additive, immobilized on cellulose-based paper to enable sustainable, non-destructive freshness detection. With the growing demand for eco-friendly and intelligent packaging, innovations in food quality monitoring are increasingly important. Anthocyanins, known for their pH-sensitive color-changing properties, offer an effective and environmentally friendly solution. This research integrates black carrot anthocyanins with cellulose substrates to create a versatile, food-safe freshness monitoring tool that supports sustainability and technological advancement.

The indicator was developed by physically immobilizing anthocyanins onto a cellulose matrix using non-chemical methods. Its colorimetric behavior was evaluated across a pH range of 2 to 10. Structural characterization was conducted using field emission scanning electron microscopy, Fourier-transform infrared spectroscopy, and X-ray diffraction, while tensile strength analysis confirmed mechanical stability. The indicator's efficacy was tested by packaging button mushrooms in biodegradable trays stored at ambient (25±1°C) and refrigerated (5±1°C) conditions, with concurrent monitoring of physicochemical changes and volatile organic compound release.

The indicator showed a color transition from light pink in acidic conditions to spruce blue under alkaline conditions. Structural analysis confirmed effective anthocyanin deposition and a porous morphology. Fourier-transform infrared spectroscopy revealed hydrogen bonding between anthocyanins and cellulose, while X-ray diffraction showed a slight reduction in crystallinity post-immobilization. Mechanical testing confirmed unchanged tensile strength. The indicator categorized mushroom freshness into three stages: "Fresh" (Days 1–4), "Still Fresh" (Days 6–8), and "Spoiled" (Day 10). A strong correlation ($r = 0.93$) was observed between color changes and key quality attributes, particularly weight loss, with principal component analysis validating the freshness separation. This colorimetric system provides a sustainable, non-destructive tool for real-time freshness monitoring, enhancing postharvest management and reducing food waste.

Assessment of Genetic Diversity using Molecular and Biochemical Approaches in Kodo Milet (Paspalum scrobiculatum)

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Kodo millet (*Paspalum scrobiculatum*) is a nutrient-dense, drought-resistant grain that plays an essential role in promoting food security, particularly in semi-arid regions. Known for its high fiber content, protein, and essential minerals. . A set of seventy-six germplasm including check JK41 lines were evaluated in Randomized Complete Block Design during Kharif 2021 to study different biochemical parameters like sugar, proline,H_2O_2 etc to assess the diversity among different genotypes.In molecular analysis,total genomic DNA was extracted by CTAB method with some modification. PCR amplification was carried out by using master cycler gradient thermal cycler.Eighty-six SSR primers unveiling polymorphism between two contrasting genotypes were employed for analysis of genetic diversity among 37 genotypes selected from 75 genotypes along with 1 check variety included germplasm lines and check varieties. A set of 83 SSR markers for diversity assessment were pre-screened, out of which 36 primers were selected and 14 showed polymorphism and rest were monomorphic. primers. The genetic diversity ranged between 0.5946 and 0.7889 for marker UPEG111 and ICECP16 respectively so as PIC values ranged between (0.5098) for UGEP111 to (0.7617) for ICECP16.

Assessment of Pre-Sowing Treatment of Seed Germination and Growth of Chironji (*Buchanania cochinchinensis*) under Agroforestry Systems in Jabalpur (MP)

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Chironji (*Buchanania cochinchinensis*) is a commercially valuable wild fruit yielding species that are declining due to exorbitant harvesting, poor seed germination with its hard seed coat and vulnerability to pests from indiscriminate cutting is leading to endangers biodiversity and industrial supply. The study aimed to evaluate the effect of pre-sowing treatment on seed germination and its impact on the growth behaviour of the Chironji under the agroforestry system.

A study was conducted for three years i.e. 2022-25 at the Tropical Forest Research Institute, Jabalpur, M.P. The pre-sowing treatments comprised T_1 (Control), T_2 (Cow dung), T_3 (Cow urine), T_4 (Mechanical scarification), T_5 (H_2SO_4) and T_6 (GA_3), in a Completely Randomized Design with three replications. Germination parameters (Days taken to germination, germination percentage, seed vigour and survival percentage), while post-emergence (shoot height and diameter, leaf count) were recorded. The subsequent experiment was undertaken with the transplantation of seedlings (T_6) within an agroforestry system. Growth metrics were assessed across treatments viz. AF_1 (Chironji 6x6m + maize), AF_2 (Chironji 6x6m + cowpea), AF_3 (Chironji 6x6m + kalmegh), AF_4 (Chironji 8x8m + maize), AF_5 (Chironji 8x8m + cowpea), AF_6 (Chironji 8x8m + Kalmegh), AF_7 (Sole Chironji 6x6m) and AF_8 (Sole Chironji 8x8m), conducted in Randomized Block Design with three replications.

The study found that T_6 (GA_3) treatment registers significantly higher germination and post-emergence parameters as compared to T_1(Control), while growth parameters including plant height and collar diameter over two years, were maximum under AF_8 followed by AF_7, AF_6, AF_5, AF_4, AF_3, AF_2 and AF_1, which increased the growth of Chironji. These findings suggest that GA3 treatment is optimal for enhancing Chironji seed germination, while wider spacing in agroforestry systems supports better growth and development.

A Novel Nanoporous Carbon from Chickpea Stalk Residue for the Supercapacitor Electrode

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In energy storage, three key devices are utilized: capacitors, supercapacitors, and batteries. Among these, supercapacitors stand out due to their high specific capacity, superior power density, and extended life cycle. However, their limited energy density remains a significant barrier for their widespread application. Addressing this requires innovative solutions, particularly the development of advanced electrode materials. One promising approach is the use of agricultural crop residues as precursors for electrode development. This strategy not only enhances the performance of supercapacitors but also aligns with sustainable and environmentally friendly practices by leveraging renewable resources. Moreover, it creates economic opportunities for farmers by adding value to agricultural byproducts, promoting a circular economy, and contributing to climate change mitigation efforts.

Among the different agricultural biomass, chickpea stalk was taken as the raw precursor. The raw precursor was impregnated with potassium hydroxide and then thermally treated at different activation temperatures with activation times. The produced nanoporous carbon was used as electrode material. The electrode was prepared with a ratio of 70:10:20 (weight%) of active material (nanoporous carbon), conductive agent and binder. The electrode material was tested on a three-electrode electrochemical workstation. The cyclic voltammetry analysis, cyclic charge-discharge analysis, electrochemical impedance spectroscopy analysis and cyclic stability performance were evaluated.

The study revealed that the developed nanoporous carbon derived from chickpea stalk exhibits exceptional electrochemical performance, surpassing other biomass-based materials. The findings demonstrated that the novel electrode material possesses a high specific surface area with an interconnected network of micro- and mesopores. These structural features significantly enhance ion storage capacity and facilitate efficient ion transport within the supercapacitor. Electrochemical testing highlighted a specific capacitance of 343.29 F/g with energy density of 48 Wh/kg, and a power density of 495 W/kg. Furthermore, the electrode material demonstrated excellent stability with a long cycle life, indicating its suitability for sustainable energy storage applications. The research underscores the importance of utilizing renewable agricultural residues to develop advanced electrode materials for supercapacitors. This approach not only advances energy storage technology but also aligns with sustainable practices by adding value to agricultural byproducts. The findings offer a pathway for integrating renewable resources into high-performance energy solutions, contributing to both technological and environmental progress.

Genotypic Screening and Trait-based Analysis of Sesame Against Mirid Bug (*Nesidiocoris tenuis)*

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Sesame (*Sesamum indicum L.*) is an important oilseed crop, valued for its high oil (50%) and protein (20%) content. However, its productivity in India is low and fluctuates, with insect pests, particularly the mirid bug (*Nesidiocoris tenuis*), significantly affecting yield. Identifying resistant genotypes is crucial for developing pest-resistant varieties and sustainable pest management strategies. This study screened 54 sesame germplasm lines and four checks (two resistant: SI-250, GT-10; two susceptible: TC-25, Prachi) for resistance to mirid bugs under field conditions. Resistance was assessed by mirid bug population density per plant. Selected genotypes were further analyzed for key morphological and biochemical traits to understand resistance mechanisms.

The experiment used a randomized block design (RBD) with three replications, planting each genotype in 3 m rows with 30 cm × 10 cm spacing. Weekly observations of nymphs and adults were recorded on five randomly selected plants per genotype. Based on field screening, 15 genotypes were selected for further study. Morphological traits (plant height, capsule count, leaf thickness) and biochemical parameters (total phenol, total ash content, total protein, total sugar, reducing sugar, and tannins) were analyzed at 30, 45, and 60 DAS, and correlations with mirid bug populations were assessed.

The study revealed significant variation in mirid bug infestation among genotypes, with some showing strong resistance and others high susceptibility. Correlation analysis indicated that specific morphological and biochemical traits played a crucial role in determining resistance levels. Higher phenol, tannin, reducing sugar, and total ash content were linked to lower insect populations, suggesting their role in resistance. Conversely, higher total protein and total sugar levels were associated with increased susceptibility. These findings offer valuable insights into the mechanisms of mirid bug resistance in sesame, aiding breeding programs for resistant cultivars and sustainable pest management.

Spraying Fusarium wilt Affected Plant Extract Induces Tolerance Against Fusarium wilt by Modulating Physiology and Stress Mitigating Activities in Chickpea (*Cicer arietinum* L.) Plant

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Biotic and abiotic stresses reduce chickpea yields, with Fusarium wilt causing 20-40% loss or total crop failure. Chemical controls are costly and ineffective. Research suggests using organic, biological alternatives to manage plant diseases, offering a potential substitute for fungicides in improving plant resistance.

Experiments were undertaken in the years 2020-2021 and 2021-2022 at Herbal Garden Department of Plant Physiology, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP), to study the comparative effectiveness of the sterilized *Fusarium oxysporum ciceri* wilt affected plant extract and wilt infected soil extract with synthetic plant growth regulators (ABA- Abscisic Acid , NAA- Naphthalene Acetic Acid, and SA-Salicylic acid) and fungal toxin (Fusaric acid) against Fusarium wilt in resistant (Rajas variety) and susceptible(JG 74 variety) chickpea plant artificially exposed wilt inoculums.

For the current investigation, variables pertaining to yield, its contributing feature, $CO_2/H_2O/O_2$ exchange physiology, stress tolerance response and biochemical performance were selected and the response of plant modulators and traits that were the source of higher crop plant yields under wilt induced conditions were identified. The maximum induction of tolerance in chickpea in both susceptible and resistant variety was prominently seen when sprayed either with wilt affected plant extract @ 20 ppm or ABA @ 5 ppm in terms of lesser incidence of symptoms of wilt in crop in spite of deliberate exposure to wilt. Spraying of either of 20 ppm disease infected plant extract or of 5 ppm ABA was equally and highly effective in maximizing photosynthetic rate, chlorophyll content, water use efficiency, more accumulation of compatible solute (proline), stress mitigating processes and ROS (Reactive Oxygen Species) scavenging enzymes in one hand and reduced stomatal conductance, transpiration rate and vapor pressure deficit in other hand. Spraying of disease infected plant extract helps in inducing Fasarium wilt tolerance by enhancing physiological, biochemical and molecular fitness of plant to resist wilt infection in spite of deliberate inoculation of disease in planting mixture. Although, plant extract @20 ppm was found to be equally effective as ABA @ 5 ppm but, plant extract is organic, eco-friendly and cost-effective. Hence, plant extract is found to be the best alternative organic option for managing Fusarium wilt in chickpea.

Efficient Iot-enabled Early Soybean Leaf Disease Detection System

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Agriculture in India faces challenges like nutrient fluctuations, inefficient resource use, and inadequate data. This study introduces a novel framework for early disease detection in soybean crops, combining a memristive system, convolutional neural network (CNN) model, and a mobile application. Traditional methods face challenges like high energy consumption, large area requirements, and prolonged processing times. The proposed system overcomes these limitations by leveraging memristive technology and AlexNet for efficient data processing, image decomposition, and classification, making it accessible through a user-friendly mobile app for farmers and agricultural stakeholders.

The methodology integrates Wavelet Packet Transform (WPT) for image pre-processing and AlexNet, a pre-trained CNN model, for classification. A dataset comprising soybean leaf images of 11 disease classes was divided into 30% training and 70% testing subsets. Image augmentation techniques were employed to enhance classification accuracy, while the memristive model optimized image decomposition coefficients for CNN input. The mobile application is designed to capture images, process them in real-time, providing disease-specific recommendations based on the classification results.

Observations demonstrated superior performance metrics: 94.30% accuracy, 99.66% precision, and 99.65% sensitivity, outperforming conventional CMOS-based CNN systems. The mobile app enables rapid disease detection and provides tailored agricultural guidance, making the system practical for real-world applications. By reducing energy consumption and compression ratios, the memristive framework addresses IoT challenges, ensuring scalability and resource efficiency. This integrated approach promotes sustainable farming by providing cost-effective, accurate, and timely disease management solutions, empowering farmers to enhance crop yield and resilience through advanced diagnostics.

Effect of Nano-Biofertilizer (Fe_2O_3+ *Bradyrhizobium japonicum*) on the Growth and Development of Soybean

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Nano-biofertilizers (NBFs) present a sustainable and cost-effective strategy for improving plant growth and crop yield. This study explores the effects of Fe_2O_3 NPs combined with *Bradyrhizobium japonicum* (*B. japonicum*) on the physiological parameters of soybean plant (*Glycine max*).

Impact of Fe_2O_3 NPs on bacterial growth was assessed. Soybean seeds were primed with varying concentrations of Fe_2O_3 NPs mixed with *B. japonicum* for different priming time to identify optimal priming conditions. The effect of priming by NBF on germination parameters, growth analysis and chlorophyll fluorescence were measured.

Screening of bacterial growth in Fe_2O_3 NPs concentrations (1–200 mg/L) revealed optimal growth up to 10 mg/L. Soybean seeds were primed with Fe_2O_3 NPs (1 mg/L and 10 mg/L) and *B. japonicum* for 1–5 hours, where 3 to 5 hrs priming showed best results. Growth metrics, including biomass, chlorophyll content, nodulation, and root length, were significantly enhanced at the R1 growth stage. 3 hr Nanoprimed plants exhibited highest chlorophyll levels and improved photosynthetic performance, with enhanced water-splitting activity (Fv/Fo), active reaction centers, energy trapping efficiency, electron transport, and a higher performance index (PI). Fe_2O_3-NBF demonstrates potential as a smart fertilizer, improving nodulation, photosynthetic efficiency, and stress resilience, contributing to sustainable agriculture.

Discerning Heat-Tolerance in Advanced Breeding Lines of Chickpea through Multi-Model based Stability Analysis in Multi-Environmental Trials

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Chickpea (*Cicer arietinum* L.), considered as poor man's meat serves as an inexpensive source of high-quality protein and essential micronutrients, offering a practical solution for addressing malnutrition. Heat stress (>32°C) at reproductive stage, severely constrains chickpea production, resulting in yield losses of up to 39%. Farmers often face delays in sowing chickpea due to the late harvest of preceding crops such as paddy, which exposes the crop to heat stress and threatens yield stability. The objective of this study is to identify heat-tolerant chickpea genotypes that enable delayed sowing without substantial yield losses, ensuring yield stability and economic resilience for farmers.

The experiment included thirty advance breeding lines sown in three dates of sowing in two consecutive seasons (*Rabi* 2022-23 and 2023-24), resulting in a total of six environments. Different models like additive main effect and multiplicative interactions (AMMI 1, AMM2), scores of best linear unbiased prediction (BLUPs), and genotype plus genotype x environment (GGE) interactions were executed utilizing grain yield to understand their suitability in the precise estimation of variance and their interaction.

The combined analysis of genotype stability index (GSI) using AMMI and best linear unbiased prediction (BLUPs) scores revealed that genotype JG2022-9, ICC181108, JG2022-10 found to be the high yielding and stable genotypes across the environments. The which–won–where pattern of GGE biplot analysis indicated that the target environment consists of three mega environments. JG2022-2 and RVG204 considered potential genotypes for ENV I and IV, while ICC181108-1 for ENV, II, IV, III and VI. JG2022-9, ICC181108, JG2016-9651 and JG2022-10 considered promising genotypes based on their proximity in GGE ranking biplot. Based on the above findings, JG2022-9, ICC181108, JG2022-10 and JG2016-9651 identified as heat tolerant genotypes being suitable for delayed sowing conditions.

Assessment of Orange Growers Knowledge towards Orange Cultivation Practices in Madhya Pradesh

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Madhya Pradesh is second largest producer of orange in India. The present study on the knowledge level of orange growers in the Agar Malwa and Pandhurna districts of Madhya Pradesh. As these districts produce more than 50 per cent of total orange production in the state, and these districts also come under one district one product in orange. From each districts, 2 block were selected. Thus from Pandhurna district Sausar and Pandhurna blocks and from Agar Malwa district Susner and Nalkheda blocks were selected because of higher orange production. From each selected block five villages were selected based on the maximum number of orange growers. Thus, a total of 20 villages were selected from 4 blocks.

Yemne's proportional stratified sampling approach used to identify the number of farmers from each village. Total 183 farmers were selected. The data were collected by personally interviewing the respondents with the help of pretested interview schedule. The sequential exploratory mixed-method research design was employed to elucidate the complexities of the research problem, facilitating a comprehensive and nuanced understanding.

The result revealed that the 48.63 per cent of the orange growers had medium level of knowledge on orange cultivation technology, followed by 27.32 percent of growers had high knowledge and only 24.04 per cent of growers had low knowledge on orange cultivation technology. This study serves as an essential resource for understanding orange growers knowledge deficits in orange cultivation. The study highlights the need for region-specific interventions on plant protection, nutrient management and tailored extension services to address knowledge gaps and promote sustainable orange cultivation practices.

Effect of Biofertilizers (Rhizobium and PSB) with and without Molybdenum on Nodule Formation, Growth, and Yield, of Chickpea (*Cicer arietinum* L.)

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Chickpea (*Cicer arietinum* L.) is an important leguminous crop known for its ability to fix atmospheric nitrogen through symbiosis with rhizobia, reducing dependence on synthetic fertilizers. This study investigates the effects of biofertilizers (Rhizobium and phosphate-solubilizing bacteria [PSB]) with and without molybdenum on nodule formation, growth, and yield in chickpea. A field experiment was conducted during the rabi season of 2020-21 at the Research Farm, Krishi Vigyan Kendra JNKVV, Jabalpur, using a randomized block design with ten treatments replicated three times. Treatments included different combinations of Rhizobium (10g, 15g, and 20g), PSB (20g), and ammonium molybdate (0.5g and 1g) per kg^{-1} seed, along with a control.

Observations recorded included plant height, nodule number, nodule fresh and dry weight, leghaemoglobin content, grain yield, and straw yield. Results indicated that the application of 20g Rhizobium + 20g PSB kg^{-1} seed + 1g Mo kg^{-1} seed led to the highest plant height, nodule count, nodule weight, and grain yield, which was statistically similar to 15g Rhizobium + 20g PSB kg^{-1} + 0.5g Mo kg^{-1} seed. These treatments significantly enhanced nodulation, nitrogen fixation, and overall plant development compared to the uninoculated control.

The synergistic interaction between Rhizobium, PSB, and molybdenum improved nutrient availability, leading to higher biomass accumulation and yield. The presence of molybdenum likely enhanced nitrogenase enzyme activity, further facilitating biological nitrogen fixation. These results suggest that integrating biofertilizers with molybdenum is a promising strategy for improving nodulation, growth, and yield in chickpea. This approach not only enhances productivity but also promotes sustainable agriculture by reducing reliance on chemical fertilizers.

Tunable Effect of Divalent Cations on Tendril Patterning During Swarming Motility of *Pseudomonas Aeruginosa* Through Chemical Engineering Approach

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Pseudomonas aeruginosa shows swarming motility, a group motility behaviour to colonize diverse environment. It involves formation of dendritic like colony morphology called tendril patterns. While this colonization ability is beneficial for bioremediation, it poses significant challenges during host infection. The lack of a standardized swarming media has hindered our understanding of how to fine-tune this group-motility behaviour to meet specific requirements. We sought to determine if environmental engineering could effectively tune *Pseudomonas aeruginosa* swarming motility. Here, we engineered a swarming minimal media (SM). Using this single media, we demonstrated that dose-dependent divalent cations especially magnesium and calcium, can tune *P. aeruginosa* swarming motility. Mechanistic insights reveal that divalent cations at colony edges stimulate cell growth and trigger quorum-sensing, leading to reduced surface charges on cells and heterogeneous rhamnolipid secretion without changing flagella number on cells. These events create a dynamic environment where bacterial cells with varying surface charges and active flagella are suspended in an aqueous-rhamnolipid colloidal solution, promoting swarming motility. To accommodate increased cell growth and differential surface charges within this colloidal solution, the bacterial community responds by increasing the number of tendrils rather than their thickness, possibly due to changes in surface tension. This adaptive strategy raises further questions about the sophisticated ways in which bacteria respond to environmental cues. The significance of our study lies in modulating the environmental distribution of divalent cations to allow or restrict the distribution and colonization of the growing bacterial population in different contexts.

Sustainable Energy Solutions through Urea Electrooxidation: Insights into Ni and Fe-based LDH, LDO, and Hydroxides under Different Dissolved Gas Saturation Conditions in Electrolyte

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Interest in sustainable energy solutions has increased due to environmental concerns, non-renewable resource depletion, and rising energy consumption. With an emphasis on urea electrooxidation, urea-based wastewater presents a viable substitute for fuel cells and hydrogen production. This work investigates hydrothermally produced NiFe LDH, NiFe LDO, and $Ni(OH)_2$ electrocatalyst, evaluating the function of iron and maximizing efficiency through operating condition optimization.

The as-synthesized electrocatalyst was characterized using XRD, FESEM-EDS, Raman, FTIR, and XPS. Electrochemical studies used cyclic voltammetry, chronoamperometry and electrochemical impedance spectroscopy with varied urea/NaOH concentrations and gas purging conditions to optimize urea electrooxidation performance, focusing on catalytic efficiency under different electrolyte environments.

The superior performance of NiFe LDH compared to other catalysts is observed due to easy charge transfer facilitated by Fe ions. Moreover, Fe incorporation prevents surface poisoning of the electrocatalyst, resulting in increased activity and stability for electrocatalytic urea oxidation reaction. Additionally, the low Tafel slope of 45.12 mV/dec for NiFe LDH showed the highest activity, surpassing NiFe LDO (54.05 mV/dec) and $Ni(OH)_2$ (87.39 mV/dec).The influence of different electrolyte environments on the performance of urea-based electrolyzers for sustainable hydrogen production and management of urea-rich wastewater has been measured for the first time by varying oxygen saturation and nitrogen purging conditions. In cyclic voltammetry studies, O_2-saturated and purging conditions outperformed N_2 gas saturation or purging. The findings of this study provide valuable insight into the design of practical and environmentally friendly urea electrooxidation systems.

2D Graphene Oxide and MXene-based Materials for Hydrogen Storage

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The depletion of traditional energy sources has accelerated the global shift toward renewable energy solutions, with hydrogen energy emerging as a clean and efficient alternative.[1] As a key component of a sustainable energy system, the widespread adoption of hydrogen depends heavily on developing safe and effective storage technologies. Among the various approaches, material-based hydrogen storage systems have gained significant attention due to their safety, efficiency, and scalability compared to conventional methods such as compression and liquefaction.

The development of palladium-decorated reduced highly functionalized graphene oxide (Pd-rHGO) as an innovative hydrogen storage material. The Pd nanoparticles are decorated onto HGO using an impregnation method. This one-pot approach not only reduced HGO but also facilitated the uniform distribution of Pd nanoparticles on graphene sheets. Further, the $Ti_3C_2T_x$ MXene, a young 2D material, was synthesized from the chemical etching of the aluminium layer from the Ti_3AlC_2 MAX phase. Additionally, the GO-$Ti_3C_2T_x$ MXene was also developed using chemical methods by individual precursors in optimized proportion at optimized conditions.

The optimized Pd-rHGO nanocomposite demonstrated an impressive hydrogen uptake capacity of 6.62 wt% under nearly ambient conditions, surpassing the U.S. Department of Energy (DoE) targets for hydrogen storage materials.[3] The $Ti_3C_2T_x$ MXene reveals a hydrogen storage capacity of 10.47 wt% at 77 K and 25 bar.[4] Further, the GO-$Ti_3C_2T_x$ MXene composite reveals a hydrogen storage capacity of 5.08 wt% at room temperature and 30 bar hydrogen pressure.[5] The performance of these materials can be attributed to their layered morphology and surface functional groups, which provide a high surface area and efficient hydrogen adsorption sites. Additionally, the ambient operating conditions and improved storage capacity of the developed material highlight its practical use in compact, lightweight, and efficient hydrogen storage systems.

Nickel-Modified Hollow Mn PBAs as a Durable and Efficient Cathode for Sodium-Ion Batteries

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To achieve the goal of high energy and power in a sustainable, safe, and cost-effective way, Prussian Blue Analogues (PBAs) have gained attention as promising cathode materials for sodium-ion batteries (SIBs). Their unique open-framework structure supports rapid ion transport, essential for high-power applications, while their composition, based on abundant and eco-friendly elements, positions them as a green alternative to lithium-based batteries.

Manganese-based PBAs offer high theoretical capacity and multi-electron redox potential, making them promising for energy storage. However, structural instability and capacity fading limit their application. This study addresses these challenges by synthesizing nickel-coated Mn PBA hollow cages using a self-template hydrothermal method to enhance stability and electrochemical performance.

The FESEM analysis demonstrated the evolution of a hollow cage structure in Mn PBA, with the Ni coating maintaining the structural integrity. XRD and FT-IR analyses confirmed the monoclinic phase and the presence of interstitial and absorbed water, while TGA results indicated enhanced stability with Ni coating, as evidenced by reduced weight loss. Nickel-coated Mn-PBA demonstrated a high specific capacity of 160 mAh g^{-1} at 0.01 A g^{-1} making it suitable for energy-dense and long-duration applications. Moreover, after 500 charge-discharge cycles, the material retained 81% of its initial capacity, highlighting its durability and improved cycling stability. The findings underscore the potential of nickel-coated Mn-PBAs as sustainable and efficient cathode materials for advanced energy storage systems. By addressing critical challenges in sodium-ion battery technology, this study provides a viable pathway to designing durable, high-performance materials. The combination of eco-friendliness, cost-effectiveness, and enhanced electrochemical performance makes nickel-coated Mn-PBAs an excellent choice for next-generation energy storage applications, aligning with the increasing demand for sustainable and efficient energy solutions.

Synthesis, Structure and Biomedical Applications of Mono-nuclear Ni(II) and Cu(II) Complexes with Symmetrical Bioactive Ligand

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Bioactive ligands are a broad class of compounds, having applications in biomedical issues. The double bond between the carbon and nitrogen atoms, play a significant role in bio-synthon processes. Their versatility stems from the numerous chemical ways. This work reports a fresh perspective on this class of chemicals. A new bioactive ligand L has been synthesized from 5-bromo-2-methoxybenzaldehyde and 3-Amino-4-chloro-6-nitrophenol. New mononuclear Ni(II) & Cu(II) complexes were synthesized and spectrochemically characterized by FT-IR, NMR, UV-visible, ESI-MS, Thermogravimetric analysis (TGA) and cyclic voltammetry (CV). Metal complexes show six coordinated pseudo-octahedral geometry. All the complexes are completely soluble in DMSO and DMF. Bioactive ligand and its metal complexes are biologically active. Metal complex Cu (II) shows better antimicrobial activities i.e. antifungal and antibacterial.
Keywords: Bioactive ligand, Metal complexes, Thermal, Antibacterial, Antifungal.

Dinuclear Iron(II) Triple Helicates Exhibiting Room Temperature Spin-Transition Behaviour in Solid and Solution Phase

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The phenomenon of reversible switching of spin states in 3d transition metals in the presence of external stimuli is called spin crossover (SCO). The covalent and non-covalent interactions determine the type of SCO behavior in the solid state, whereas ligand field strength affects SCO in solution. Dinuclear Fe(II) triple helicates are a class of metallosupramolecules exhibiting single as well as multi-step SCO owing to the presence of three types of spin states: complete high-spin [HS-HS] or complete low-spin [LS-LS], and an intermediate state [HS-LS].

The design strategy involves using imidazole-based Schiff base ligands that provide ligand field strength higher than the conventional triazole ligands, shifting SCO to room temperature. Three dinuclear iron(II) helicates bearing the molecular formula $[Fe_2(L1)_3](ClO_4)_4\cdot 2CH_3OH\cdot 3H_2O$ (complex **1**), $[Fe_2(L2)_3](ClO_4)_4\cdot 6CH_3CN$ (complex **2**), and $[Fe_2(L3)_3](ClO_4)_4\cdot 0.5H_2O$ (complex **3**) have been synthesized using imidazole and pyridine-imine-based ligands having fluorene moiety in the backbone (**L1**= (1*E*,1′*E*) -N, N′-((9*H*- fluorene-9,9-diyl)bis(4,1-phenylene))bis(1-(1*H*-imidazol-2-yl) methanimine), **L2**= (1*E*,1′*E*)- N,N′-((9*H*- fluorene-9,9-diy l) bis (4,1
phenylene))bis(1-(1*H*-imidazol-4-yl)methanimine), and **L3**= (2*Z*,2′*Z*)-N′,N‴-((9*H*-fluorene-9,9-diyl)bis(4,1-phenylene)). Single-crystals were obtained by vapour diffusion of diethyl ether into the methanol solution of the complexes.

A change in the ligand field strength by terminal modulation of the corresponding aldehydes led to a change in the spin transition behavior from incomplete, multi-step to complete, around room temperature in the solid state. Spin transition behavior has also been observed in the solution phase characterized using variable temperature ^{1}H nuclear magnetic resonance spectroscopy (Evans method) and correlated using UV-Visible spectroscopy. Fitting the ^{1}H NMR data using the ideal solution model yielded the transition temperature in the order $T_{½}$ (**1**) < $T_{½}$ (**2**) < $T_{½}$ (**3**), which indicates an increase in the ligand field strength on moving from complexes **1** to **3**. This study accentuates the interplay between the ligand field strength, crystal packing, and supramolecular interactions in fine-tuning the spin transition behavior effectively.

Appraisal of the Fragments-in-Fragments Method for the Energetics of Individual Hydrogen Bonds in Molecular Crystals

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We report a direct application of molecular tailoring approach based (MTA-based) method to calculate the individual hydrogen bond (HB) energy in molecular crystal. For this purpose, molecular crystals of nitromalonamide (NMA) and salicylic acid (SA) were taken as test cases. Notably, doing a correlated computation using a large molecular crystal structure is difficult. Among 15 DFT functionals, the B3LYP provides accurate estimates of HB energies closed to the CCSD(T) ones using the 6-311+G(d,p) basis set for all atoms. The direct application of the MTA-based method to these crystal structures is although straightforward.

For instance, the calculated energy suggests that three intramolecular hydrogen bonds (HBs) in NMA crystal are of stronger strength (7.3 to 17.0 kcal/mol) than the intermolecular ones (2.7 to 4.0 kcal/mol). On the other hand, intermolecular HB in SA crystal is moderately stronger (9.9 kcal/mol) than intramolecular one (8.1 kcal/mol). However, these energy calculations by the MTA-based method is very expensive. For instance, time needed to evaluate energy of all seven HBs in NMA crystal (having molecules within maximum of 15 unit-cells) is 122681 minutes (~2.7 months).

In view of this, we assessed our recently proposed linear-scaling Fragments-in-Fragments (*Frags-in-Frags*) method for estimating the single point energies of parent molecular crystal and fragments of the MTA-based method. It has been found that the estimated HB energies by the *Frags-in-Frags* method are in excellent linear agreement with their MTA-based counterparts (R^2 = 0.9993). Furthermore, RMSD is 0.12 kcal/mol, mean and maximum absolute errors are 0.10 and 0.5 kcal/mol, respectively and the standard deviation is 0.14 kcal/mol. Importantly, the *Frags-in-Frags* method is computationally efficient; it needs only 18289 minutes (~12.7 days) for the estimation of energy of all HBs in NMA crystal and 3499 minutes (~2.4 days) for all HBs in SA crystal.

Chitosan Supported Molybdenum Catalyst for One Pot Multicomponent Synthesis of 3,4-dihydropyrimidine-2(1*H*)-one (DHPM)

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Chitosan is obtained from the deacetylation of chitin which is the second most abundant biopolymer. Chitosan is an excellent support for the synthesis of heterogeneous catalysts due to its various properties such as biodegradability, low cost, easy modification into different forms such as thin films, beads and powder, insolubility in many solvents, etc. Here we have synthesized a chitosan supported molybdenum catalyst using plant extract of *Citrus sinensis*. The catalytic activity is tested for the synthesis of 3,4-dihydropyrimidine-2(1*H*)-one **(**DHPM).

The catalyst synthesis involves coating chitosan flakes with metal (molybdenum) by simply mixing together in an aqueous solution. To this plant extract of *Citrus sinensis* was added which acts as reducing and stabilizing agent. The prepared catalyst was characterized using various analytical techniques such as X-Ray Diffraction (XRD), Scanning Electron Microscopy with Energy Dispersive X-Ray Analysis (SEM-EDAX), Fourier Transform Infrared (FTIR) and X-Ray Photoelectron Spectroscopy (XPS). The application of the catalyst was investigated for one pot multicomponent synthesis of DHPM, and the reaction conditions were optimized to obtain the best possible yield. The reaction product DHPM was characterized using Nuclear Magnetic Resonance (NMR), FTIR and UV-Vis Spectroscopy.

The synthesis of DHPM resulted in 90% yield under optimized reaction condition when the reaction was catalysed using chitosan supported molybdenum catalyst. The optimized reaction parameters are, reaction time of 4h, reaction temperature of 70°C, catalyst metal loading of 0.50mmol and catalyst concentration of 25mg. The reaction was monitored using Thin Layer Chromatography (TLC). The catalyst is stable, economical, biodegradable, nontoxic and recyclable without significant loss in activity up to several cycles.

Atomic Absorption Spectrophotometer Determination of Heavy Metal Concentrations in Drinking Water of Chhindwara District (M.P.) INDIA

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The present research work is oriented on water quality and concentration of heavy metals such as Co, Ni, Fe, Mn, Cu, Zn, Cr, Cd, Pb, and As, in the drinking water of Chhindwara District of Madhya Pradesh. This study has been conducted to identify the quality of drinking water, in various Tehsil (Block) falling under the Chhindwara region. Drinking water quality depends on its physicochemical and biological parameters. In this research work, a water sample was collected from all blocks of the Chhindwara district. It analysed the concentration of all heavy metals like Co, Ni, Fe, Mn, Cu, Zn, Cr, Cd, Pb and As with the help of an atomic absorption spectrophotometer (AAS). In this work approx all Physicochemical parameters such as Temperature, pH, Turbidity, Total hardness, Alkalinity, Total Dissolved Solid, Chemical Oxygen Demand, Biochemical Oxygen Demand, and Dissolved Oxygen are measured by the various test methods of the different places samples, using standard procedures and the results are compared with other national and international acceptable level.

Bridging the Gap Between E-Waste and Water Security: Exploring the Fluoride Removal Potential of Waste Toner

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With the rapid growth in the use of electronic and electrical devices, the disposal of printer cartridges has become a significant environmental concern, contributing to electronic waste. These cartridges contain toner powder, a composite material comprising carbon, Fe_3O_4, polypropylene, and SiO_2. This study aims to develop a sustainable and cost-effective method to recycle this waste toner powder as an adsorbent for fluoride removal from water. The research highlights the potential of printer cartridge toner (PCt) to address fluoride contamination, a global issue threatening safe drinking water.

The toner powder was extracted from used printer cartridges and characterized using advanced techniques such as XRD, FTIR, and SEM to understand its composition and morphology. Batch adsorption experiments were conducted to evaluate the fluoride removal efficiency under varying conditions of pH, temperature, and adsorbent dosage. Isotherm models (Langmuir and Freundlich) were applied to study adsorption behavior, and kinetic models were utilized to determine the process mechanisms. Additionally, fixed-bed column studies and real-water tests were performed to assess practical applications.

The PCt demonstrated a remarkable fluoride adsorption capacity of 60 mg/g, supported by its specific surface area of 20 m^2/g. The adsorption process was spontaneous and exothermic, as confirmed by thermodynamic analysis ($\Delta G < 0$, $\Delta S > 0$). The material exhibited reusability for three cycles with minimal performance loss. Fixed-bed column experiments validated its industrial feasibility, while tests on real groundwater samples reduced fluoride levels below WHO's permissible limits. This study underscores the dual environmental and economic benefits of transforming electronic waste into a valuable resource for water treatment, promoting a circular economy.

In- silico Analysis of Van Tulsi (*Ocimum gratissimum L*) for Antidiabetic

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Diabetes Mellitus (T2DM) is the most common kind of diabetes in the world. In this work, 239 chemicals from the plant ocimum gratissimum L. were examined using in silico computational techniques, including molecular dynamics modeling methodologies, against the human pancreatic alpha amylase (HPA) in order to prevent and manage type 2 diabetes (T2D), which involves regulating the rise in dietary glucose levels. investigation of protein-ligand interactions, docking of molecules, molecular dynamics, and computation of binding free energy. Four compounds are under investigation, with the best negative docking scores falling between 4 and 5. The docking scores of the control ligand, Myricetin (7.8 Kcal/mol), were higher than those of 4Carvomenthenol (-9.7 Kcal/mol), Menthofuran (-7.6 Kcal/mol), Zicanene (-7.5 Kcal/mol), and Thujopsen (-7.4 Kcal/mol). The molecular dynamics analysis revealed that the top two docked compounds showed a high degree of stability in the active region of the protein. As a result, both compounds identified in our investigation are recommended as possible antidiabetic options and warrant more in vitro and in vivo research.

Design and Synthesis of Peptide Based Nanohybrid Metallohydrogel as Bifunctional Electrocatalyst for Urea Oxidation

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The peptide based nanohybrid metallogel with high structural flexibility and multi functionality emerging as a new functional material in the field of energy conversion. The objective of our study is to create the peptide based metallohydrogel for their efficient utilisation in water oxidation and urea oxidation reaction at ambient condition. Herein, we have synthesised a peptide based linker FF-AdiA-FF (AdiA = Adipic acid, F-L phenylalanine) using solution phase synthesis and prepared a metallohydrogel with $NiCl_2.6H_2O$. To prepare the metallohydrogel, 18.37 mg (25 mmol) of linker is use with 3 mg of $NiCl_2.6H_2O$ in the final volume of 1 mL. The metallohydrogel were characterised by FT-IR, SEM, TEM, XRD and rheology. The metallohydrogel exhibit outstanding activity toward the oxygen evolution reaction (OER) and urea oxidation reaction. The nanofibrillar morphology of the metallohydrogel enhances the active surface area of electrocatalyst during the electrochemical analysis which is advantageous for the high activity of the electrocatalyst. For OER the metallohydrogel require the small overpotential of 240 mV to acquire the benchmarking current density of 10 mA cm^{-2}. Similarly, for urea oxidation the electrocalalyst require the low overpotential of 50 mV to reach the 10 mA cm^{-2} in the alkaline solution having 0.5 mmol of urea, which is lower than the overpotential require for water oxidation. Furthermore the chronopotentiometry analysis shows that the electrocatalyst is highly stable for up to 20 h at 10 mA cm^{-2} current density.

Dendrimer-Encapsulated Trimetallic Nanoparticles: A Robust Catalyst for Efficient Coupling Reactions

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Dendrimer-encapsulated trimetallic nanoparticles (Cu-Ni-Pd) synthesized via a co-complexation method to enhance catalytic efficiency in Suzuki-Miyaura carbon–carbon coupling reactions. Dendrimers provide a robust framework for nanoparticle stabilization, and the trimetallic system offers synergistic catalytic properties for mild, efficient cross-coupling of aromatic iodides and chlorides with phenyl boronic acids. Trimetallic nanoparticles were synthesized using a co-complexation approach within a dendrimer matrix. The catalysts were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDX). The catalytic reactions were performed in an ethanol-water mixture (3:1) using Na_2CO_3 as the base, with chlorobenzaldehyde as a model substrate. The dendrimer-supported Cu-Ni-Pd nanoparticles demonstrated excellent catalytic activity, achieving a 99% yield of 4-phenyl benzaldehyde from chlorobenzaldehyde in less than 2 hours. The catalyst was recyclable for up to seven cycles without significant loss of activity and could be easily separated by filtration. These findings highlight the stability, ease of preparation, and effectiveness of the catalyst under mild reaction conditions, making it a promising tool for green chemistry applications.

Residue Specific Chemical Technology for N-Gly Modification of Therapeutic Proteins

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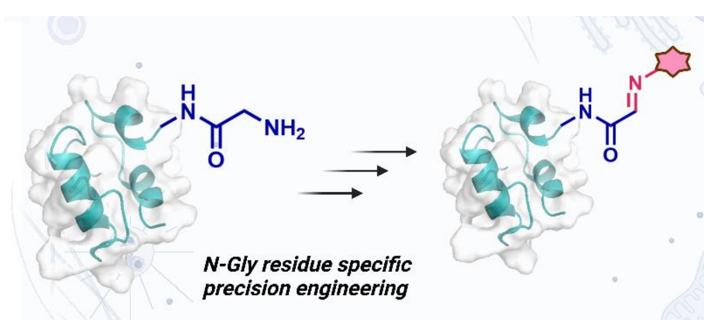
Proteins play a pivotal role in regulating and monitoring biological functions. Hence, their precise engineering garners interest from diverse segments, including biologics and therapeutics. The pre-engineered proteins with orthogonal native and non-native handles paved the way for initial success in the field. However, engineering proteins in its native forms always remain very challenging. In this perspective, chemical methods offer a unique opportunity for single-site labeling of proteins.

We developed site-specific bioconjugation technology that targets easy-to-engineer N-terminus glycine in proteins with remarkable selectivity.[1] The Gly tag® reagent comprises of an aromatic aldehyde equipped with H-bond accepter. It differentiates N-Gly as a unique target amongst other proteinogenic amino acid residues. Aldehydes are one of the versatile functionalities which remain elusive in native proteins and are capable of selective late-stage manoeuvring in the presence of proteinogenic residues. Here, we demonstrate that N-terminal Gly could be transformed into a series of chemically orthogonal functional groups in a residue-specific workflow.[2] The N-Gly-specific biorthogonal handle glyoxamide generation in proteins allows single-site modification of N-Gly protein in isolated form and the complex mixture of proteins. In this chemical workflow, all three steps are operationally simple and can be performed under mild conditions. The high efficiency of each of these steps: N- terminal Gly to aminoalcohol, then to glyoxamide, and finally to oxime, is noteworthy.

The resulting aldehyde enables parallel installation of probes and a purification platform to render analytically pure single-site tagged protein. Installation of a biorthogonal handle on therapeutic protein such as Insulin enables installation of tags to modulate its pharmacokinetic and pharmacodynamic properties. In this perspective, we engineered Insulin at N-terminus Gly with aldehyde, alkyne, azide and other probes without perturbing its structure, receptor binding, and downstream signaling pathway. Hence, N-Gly-glyoxamide-enabled precisely engineered bioconjugates offer promising insulin candidates for therapeutic applications.



Self-Assembly of Water-Filled Molecular Saddles to Generate Diverse Nanoarchitectures and High Proton Conductivity

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This study aims to design and synthesize **P2Mac**, a novel organic macrocycle derived from the pyridine-2,6-dicarboxamide (PDC) framework, for efficient solid-state proton conduction. The research focuses on leveraging molecular design and self-assembly to create high-performance, single-component organic proton conductors, addressing the need for lightweight, processable, and environmentally friendly materials.

P2Mac was synthesized and characterized using HR-MS, NMR, and SC-XRD. Its self-assembly into diverse morphologies was controlled by varying solvent conditions. Proton conductivity was measured using electrochemical impedance spectroscopy (EIS), with DFT calculations providing insights into molecular packing and charge transfer interactions. Morphological analysis was performed using FESEM and TEM.

The study revealed that, **P2Mac** adopts a saddle-shaped geometry with one water molecule in its central polar cavity, which is stabilized by five hydrogen bonds, as evidenced by the crystal structure. We could self-assemble **P2Mac** into diverse morphologies, such as octahedrons, hexapods, as well as hollow nanoparticles, and microrods, through the use of different water/THF ratios and addition rates. Interestingly, the addition of H_2O to the system aids in stacking the **P2Mac** molecules and results in the formation of long rod-shaped crystals, which were further studied for proton conductivity. The **P2Mac** crystals show very high conductivity values up to 21.1 mS cm^{-1} at 27 °C and 95% relative humidity, which could be employed in designing efficient SSPC material. The low activation energy (0.39 eV) further confirmed efficient proton transport. **P2Mac** represents a significant advancement in organic solid-state proton conductors, offering potential applications in energy storage, conversion devices, and sensors, while contributing to the development of sustainable energy technologies.

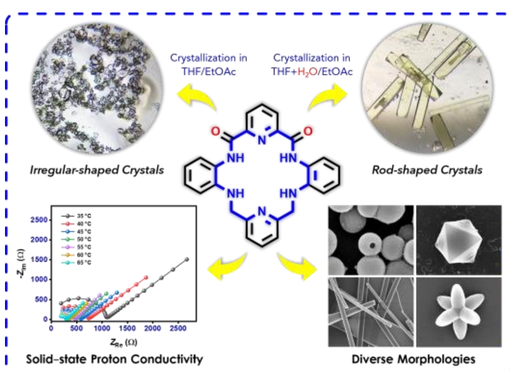

Figure. Water-filled molecular saddle stacks producing diverse morphologies and high proton conductivity.

Vertically Aligned CoFe-Layered Double Hydroxide on Carbon Substrate with Controlled Pore Size for Oxygen Evolution Reaction

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Owing to a continual rise in global energy consumption and severe environmental challenges, there is an urgent necessity for renewable and efficient energy conversion technologies. Water electrolysis is an environmentally sustainable process for hydrogen production, which is a green fuel. To date, Ir- and Ru-based catalysts are the benchmark for OER; however, their practical application is impeded by high costs and limited availability. Owing to low cost, reliability and high activity in alkaline solutions, first-row transition metals, have drawn attention as electrocatalysts for the OER.

Herein, CoFe-LDH-based carbon materials have been synthesized by co-precipitation method, wherein the growth of LDH on the porous carbon materials has been investigated. We discuss the synthesis and characterization of these LDH-porous carbon composites. Furthermore, we explain the reactivity in terms of growth orientations and pore size distribution of the synthesized nanomaterials.

Porous carbon-supported CoFe-LDH catalysts were synthesized and utilized as OER catalysts in alkaline medium. HRTEM images and N_2-sorption experiments suggested vertical growth of LDH on carbon support and narrow mesoporous nature of the materials. The surface oxygen functional groups of carbon materials provided the nucleation sites for the crystal growth of the LDH utilizing short-range electrostatic interaction, which led to vertical growth of LDH with narrow mesoporous nature. CoFe-LDH/MMC showed a remarkable mass activity of 559.2 A g^{-1} and a TOF of 4.22 s^{-1}. This excellent reactivity has been attributed to: (a) the vertically aligned narrow mesoporous nature of the material that increased the electrolyte accessibility inside the material, (b) the high electrical conductivity of the material reduced resistance for both charge transfer at the electrode/electrolyte interface and intermediates formation during water oxidation, (c) the increased electron contribution to the 3d orbital of cobalt from carbon weakened the Co-oxygen bond, thereby further facilitating O–O bond formation and O_2 desorption during water oxidation.

Photocatalytic Degradation of Organic Pollutants by a Novel Nanocomposite S,N-CQDs/$ZnCo_2O_4$ photocatalyst

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Discharge untreated wastewater from the textile industry is one of the most serious problems. Synthetic dyes are used in large amount in textile and other industries. Advanced Oxidation Processes (AOPs) have proved to be a promising technology for the complete degradation of organic pollutants at ambient conditions. It is innovative green and eco-friendly method because it degrades dyes into harmless compound CO_2 and H_2O.

Firstly we prepared $ZnCo_2O_4$ nanoparticle by coprecipitation method with using $Zn(NO_3)_2.6H_2O$, $Co(NO_3)_2.6H_2O$, PEG(MW:600) and 0.1M NH_4OH solution. Then hydrothermal method is used to prepare S,N-CQDs with using ascorbic acid and thioura. After then S,N-CQDs/$ZnCo_2O_4$ nanocomposite prepared by impregated method using $ZnCo_2$O4 nanoparticles and S,N-CQDs with specific weight ratio.

Synthesized S,N-CQDs/$ZnCo_2O_4$ nanocomposite was characterized by X- ray diffraction (XRD), field emission scanning electron microscopy (FESEM), and energy dispersive x-ray (EDX), high resolution transmission electron microscopy (HRTEM). The photocatalytic degradation efficiency of nanocomposite was investigated by degradation of Methyl Green and its photocatalytic activity about 80% removal efficiency of Methyl Green dye was achieved within 90 min under visible light utilizing 50 mg of S,N-CQDs/$ZnCo_2O_4$ nanocomposite photocatalyst.

Blue-light Irradiated Mn(0)-Catalyzed Hydroxylation and C(sp^3)-H Functionalization of Unactivated Alkanes with C(sp^2)-H Bonds of Quinones: For Alkylated Hydroxy Quinones and Parvaquone

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Site-selective C(sp^3)-H functionalization of unreactive hydrocarbons is always challenging due to its inherited chemical inertness, slightly different reactivity of various C-H bonds, and intrinsically high bond dissociation energies. Among the available strategies, transition-metal-catalyzed, directing group-assisted, carbenoids, and radicals have been developed to achieve site-selective C(sp^3)–H functionalizations. Radicals can inherently distinguish aliphatic C–H bonds based on the difference between their BDEs and polarity; they offer solitary upgradation for selective C–H functionalizations with readily accessible feedstocks under mild conditions.

Herein, we present a site-selective C−H alkylation of naphthoquinone with unactivated hydrocarbons using $Mn_2(CO)_{10}$ as a catalyst under blue-light-irradiation without any external acid or base and pre-functionalization. The selective C-H functionalization of 3° over 2° and 2° over 1° C(sp^3)−H bonds in abundant chemical feedstocks was achieved, and hydroxylation of quinones was realized *in situ* by employing the developed methodology. This protocol provides a new catalytic system for the direct construction of high-value-added compounds, namely, *parvaquone* (a commercially available drug used to treat *theileriosis*) and its derivatives under ambient reaction conditions.

Moreover, this operationally simple protocol applies to various linear-, branched-, and cyclo-alkanes with high degrees of site selectivity under blue-light conditions and could provide rapid and straightforward access to versatile methodologies for upgrading feedstock chemicals. Mechanistic insight by radical trapping, radical scavenging, EPR, and other controlled experiments well corroborated with DFT studies suggest that the reaction proceeds by a radical pathway in which naphthoquinone forms a highly oxidizing naphthoquinonyl biradical upon light irradiation. Consequently, it couples with alkyl radical generated from Mn(0) catalytic cycle to form alkylatednaphthoquinonyl radical anion. Further, it took hydrogen peroxide radical from $Mn(CO)_5$ radical intermediate to form alkylatednaphthoquinonyl peroxide intermediate, followed by removal of water molecule leads to alkylated hydroxylated quinones under reagent-, base-, and oxidant-free conditions.

$CuFe_2O_4$@GO-NH_2 Catalyzed Synthesis, Antidiabetic Activity, Molecular Docking, Redox Behavior and *Ab Initio* Studies of [1,2,4] Triazepine Structural Motifs

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Diabetes affects a large population of the globe and is considered as a leading cause of death. Many synthetic and natural inhibitors have been developed for diabetes treatment. Herein, the present work elicits the synthesis and catalytic merits of (3-aminopropyl)triethoxysilane grafted on magnetic graphene oxide ($CuFe_2O_4$@GO-NH_2) for tailoring new scaffolds of [1,2,4] triazepine skeleton i.e.1-(2,4-dinitrophenyl)-2,5-diphenyl-8-(pyridin-4-yl)-2,3,5,6,7,8-hexahydro-1H-pyrazolo[1,5-d][1,2,4]triazepin-8-ol, followed by their biological, electrochemical and quantum computational evaluation studies. These compounds were assessed for *in vitro* and *in silico* antidiabetics activity.

The nano catalyst $CuFe_2O_4$@GO-NH_2 was prepared by sequential addition of its assembly components under ultrasonic irradiation. The heterocycles synthesized by action of isoniazid and [4,5]-dihydropyrazole derivatives as precursor in polar solvent in the presence of synthesized nano catalyst and are characterized by various spectroscopical techniques. The redox behavior was investigated using cyclic voltammetry whereas *ab initio* studies were computed at B3LYP/6-311G++(d,p) level of theory to investigate chemical reactivity and HOMO-LUMO energy gap of synthesized heterocycles.

The synthesis of catalyst and heterocycles are based on the use of sustainable resources of energy and result out in no harmful residues thus put it under the umbrella of green chemistry. Molecular docking approach considering Lamarckian genetic algorithm method unrevealed the outstanding binding interactions modes in the active sites of compounds and targets. ADMET, Lipinski's Rule and TOPKAT descriptors studies were performed that give remarkable biological compatibility and low toxicity. Thus, all these booms could serve the synthesized heterocycles as potent antidiabetic candidate in near future.

Superstructures of Copper Nanoclusters as NIR TADF Emitters: Solvent-dependent Optical and Morphological Modulation

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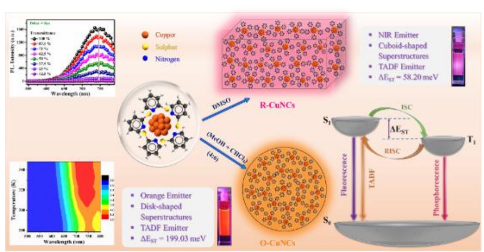
Luminescent materials that emit in the near-infrared (NIR) range, have garnered tremendous attention in the fields of chemistry, biomedical, and material science due to several advantages over conventional fluorophores, including less scattering, and greater stability. Researchers have explored the concept of Thermally Activated Delayed Fluorescence (TADF) in NIR-based luminescent nanomaterials for optoelectronics. Cadmium containing Quantum Dots have found significant success, however, these are not only toxic but also lose their photoluminesce in solid-state. To mitigate these challenges, coinage metal nanoclusters as NIR TADF emitters, characterized by low toxicity and high QYs, are considered promising candidates for manufacturing OLEDs.

Herein, we report 2-mercaptopyridine-templated copper nanoclusters (CuNCs) with NIR emission in both solid and colloidal states. The emission can be shifted to orange by using a methanol-chloroform mixture instead of water. This change in photophysical properties correlates with morphological tuning. The strong NIR emission arises from thermally activated delayed fluorescence (TADF), confirmed by long excited state lifetime, Time Resolved Emission Spectroscopy (TRES) measurements, temperature-dependent photoluminescence studies, temperature-dependent lifetime studies, and excitation-transmittance dependent TRES intensity measurements. CuNCs exhibit a small singlet-triplet energy gap (58.2 meV), indicating efficient TADF. The solvent-dependent morphological tuning of the nanocluster superstructures rendering drastic change in the photo-physical signatures is the consequence of different $\Delta E_{(S1\text{-}T1)}$ values for the CuNCs in different solvent environments.



Scheme 1: *Schematic representation of the morphological variation of the superstructures of CuNCs in two different solvent environments and their respective properties.*

Further findings corroborate that the electronic structure of the surface ligands can also help us to tune the $\Delta E_{(S1\text{-}T1)}$ energy gap for these nanoclusters. Thus, the present investigation reveals a unique methodology to prepare systems with enhanced photophysical properties that can serve as NIR TADF emitters without the use of any solid-state matrices efficiently harvesting both singlet as well as triplet state.

Regio- and Diastereoselective Synthesis of Cyclobutylated Phenothiazines *via* [2 + 2] Photocycloaddition: Photoresponsive Cell Imaging and Drug Delivery

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Phenothiazine, a key scaffold in medicinal chemistry, especially in psychiatric, antihistaminic, and antiemetic drugs, often requires harsh, multi-step synthesis with metal or base mediation. Cyclobutane, a highly strained alkane, facilitates ring expansion and fragmentation, making it a valuable building block in natural product and drug synthesis. Herein, we propose a novel visible light-mediated coupling of phenothiazine and cyclobutane, an unexplored strategy, to develop innovative bio-probes with potential biological applications.

We present a regio- and diastereoselective synthesis of cyclobutylated phenothiazines, a unique structural congener of phenothiazines, via a visible-light-mediated [2 + 2] cycloaddition, from readily available precursors, either in a two-step or a three-component coupling process. Diversifying all three coupling partners has resulted in a library of cyclobutylated phenothiazines, including post-synthetic modifications and late-stage derivatization with five commercial drugs.

After a thorough mechanistic investigation, it was found that, in contrast to the reported [2 + 2] photocycloaddition between an enone and olefin, the developed photocycloaddition proceeds *via* a ‘photoinduced-electron-transfer’ (PET) mechanism, which is well corroborated with the experimental observations, Rehm–Weller equation, and DFT computational studies. The kinetics of the [2+2] photocycloaddition and the dependency of the reaction rate on the intensity of incident light were analysed by comprehensive UV-visible absorption studies. Also, a wavelength-gated reversibility of the [2 + 2]-photocycloaddition was accomplished on the synthesized cyclobutylated phenothiazines. Monitoring the cycloreversion rates for different derivatives, revealed a structure–activity relationship (SAR). Notably, replicating this phenomenon in HeLa cells resulted in turn-on emission, enabling photoresponsive cell imaging and drug delivery. This report presents the first instance of light-triggered [2 + 2] cycloreversion in living cells, facilitating synchronized photoresponsive cell imaging and drug delivery.

Synthesis and Characterization of $NiCo_2O_4$/g-C_3N_4 Nano-Heterojunction Photocatalyst for Green and Efficient Waste Water Remediation

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The contamination of water bodies and organic pollutants is day by day worsening the water quality and rendering its toxicity to humans and the environment. To address this issue, Advanced oxidation Processes (AOPs) are believed to be the most effective and efficient process for removing toxic organic pollutants from the contaminated aqueous system.

A novel $NiCo_2O_4$/g-C_3N_4 (NCO/g-CN) nano-heterojunction photocatalyst was successfully synthesized via sustainable, cost efficient and environment-friendly process. $NiCo_2O_4$ and g-C_3N_4 were prepared by hydrothermal and thermal polymerization process respectively. Photocatalytic efficiency of nano-heterojunction was investigated by the degradation of toxic methylene blue (MB) dye using solar light as a source of radiation throughout the experiment.

The structural and morphological properties of photocatalyst have been investigated through x-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), high resolution transmission electron microscopy (HRTEM), energy- dispersive X-ray spectroscopy (EDX) and brunauer–emmett–teller (BET) analysis. The XRD data revealed a sharp intensity peak at 27.52º, and the average crystalline size of nanocomposite was 38 nm with a nano-plate like structure. An EDX spectrum showed the characteristic peaks of Co, C, N, O and Ni elements. Various optimization parameters have been discussed, and it has been found that NCO/g-CN achieved 98% degradation of toxic methylene blue dye within 120 minutes under visible light. These findings highlight the potential importance of NCO/g-CN nano-heterojunction photocatalyst for efficient, effective and sustainable waste water remediation.

Graphical Abstract:

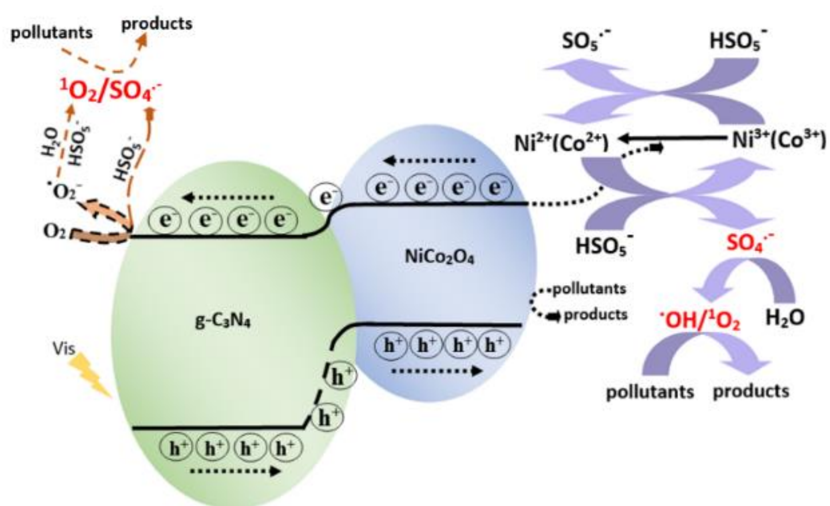

Fig: Degradation mechanism with $NiCo_2O_4$/g-C_3N_4 in vis system

Evolution of Ultrathin CoFe-Nanomesh for Enhanced Water Oxidation: Engineering Slit Pores into Ink-Bottle Pores

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Water, composed of hydrogen and one oxygen atom, is a key source of hydrogen fuel. Electrochemical water splitting, a promising method, can generate clean energy and reduce fossil fuel use. Advances in energy technologies like solar cells, Li-ion batteries, oxygen evolution, and supercapacitors depend on managing the surface area and pore size of electrocatalysts, making pore size crucial for efficient energy material development.[1]

This work elucidates the time-dependent mechanism for the CoFe-LDH nanomesh formation, utilizing 2-ethyl imidazole (2-HEIM) as an etching reagent and the Ostwald ripening process. PXRD results confirmed the LDH-like structures. Characterization techniques N_2-adsorption/desorption, and transmission electron microscopy (TEM) analyses, confirmed the evolution of pores on layered double hydroxide structure and atomic force microscopy (AFM) showed a gradual reduction in the thickness of nanomesh with the increase in synthesis time up to 24 h. Electrochemical results provide the best electrocatalyst for oxygen evolution reaction (OER).
The best catalyst $Co_{0.8}Fe_{0.2}(OH)_x$-24 h was developed after 24 h, having 3.8 nm slit-pores/ink-bottle-shaped pores on the basal plane of nanosheets with only 3–4 layers. $Co_{0.8}Fe_{0.2}(OH)_x$-24 h nanomesh exhibited the best catalytic performance with a low overpotential of 330 mV, a mass activity of 309.1 A/g, a turnover frequency of 2.28 s^{-1}, a low charge transfer (5.9 Ω) and low pseudo resistance (35.3 Ω). The best material demonstrated remarkable stability during 25 h of electrolysis with a high average current density of 14.5 mA/cm^2. Hence, this research underscores the critical role of pore morphology in nanomeshes for optimizing catalytic performance and providing stability under vigorous gas evolution due to catalysis.[2]

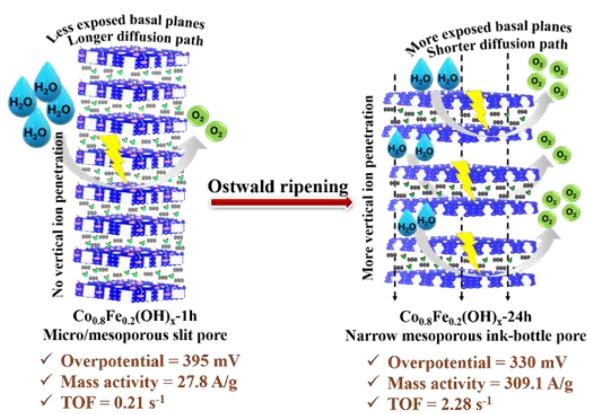

Figure. Scheme for the evolution of pore by employing the Ostwald ripening process.

Probing Local Coordination and Electronic Nature of Metal Centers in Mononuclear and Binuclear Complexes Having Salicylglycine as Primary Ligand Using XAFS

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X-ray absorption fine structure (XAFS) has been investigated at the Cu and Ni K-edges in the mononuclear complexes [(Salgly)Cu(OH_2)] **(1)**, [(Salgly)Cu(ImH)] **(2)** and imidazolate-bridged binuclear complexes [(Salgly)Cu-Im-Cu(Salgly)]Na**(3)** and [(Salgly)Cu-Im-Ni (Salgly)]Na**(4)**, where salgly=salicylglycine, Im=imidazole.

The aim of the present work is to study the local coordination geometry and electronic nature of the metal centers. X-ray absorption spectra of the complexes were recorded at the K-edge of copper and nickel on EXAFS beamline BL-9 at Indus-2 synchrotron X-ray source at RRCAT, Indore.

The crystal structures of **1** (hemihydrate and tetrahydrate forms) and **2** are known to be square pyramidal. Structures of **3** and **4** are not available. By analyzing XANES and its derivative spectra of four complexes, the local structure around Cu center in **3** and **4** have been estimated to be square pyramidal. For estimating the geometry around Ni center in **4**, the spectra at Ni K-edge has been compared with those of two standard compounds and the structure is estimated to be octahedral. For analyzing the EXAFS data for Cu K-edge of **1**-**4**, the theoretical model generated for **2** has been used for fitting, and for Ni K-edge of **4**, the theoretical model used for fitting has been generated using available crystal structure data of an analogous complex. The results obtained from fitting indicate the geometry around Cu center to be square pyramidal and for Ni center to be octahedral, i.e., same as predicted from XANES analysis. Ab initio XANES calculations have been performed using program *FEFF10* to obtain simulated XANES spectra as well as p-DOS for the metal centers. The features and shape of the simulated XANES spectra and the DOS have been compared with the experimentally measured spectra.

Dehydrative Imination, Structural Investigation of Benzil using 2-Amino-6-bromo-4-nitrophenol via Acid Catalysis and Coordinating it with Co(II) and Ni(II) and their Biological Activities

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An old-school well-known series of chemical compounds containing an imine bond said to be Schiff base, was recognized by Hugo Schiff in 1864. Despite been discovered over a century, these compounds continue to be of significant interest due to their diverse applications i.e., demonstrating their utilities from acting as an dyeing agent, as an anti-oxidant, as an epoxidizing catalyst, as an antifungal agent, as a fertilizer and many more.

Given the broad applicability of azomethine-based compounds, a novel Schiff base ligand was synthesized via an acid-catalyzed reaction between benzil and 2-amino-6-bromo-4-nitrophenol. This ligand was subsequently complexed with Co(II) and Ni(II) metal ions. The synthesized ligand and its metal complexes were thoroughly characterized using various analytical techniques, including UV-Vis spectroscopy, FT-IR spectroscopy, NMR spectroscopy, mass spectrometry, and thermal analysis.

To explore the potential applications of the newly synthesized Schiff base ligand and its metal complexes, their antimicrobial, antioxidant, and dye degradation assays were studied, which given remarkable results. Further investigations into their anti-termite, seed germination and dyeing activities are currently underway. Computational studies are also in process to determine the energetics of the synthesized compounds and correlate these findings with the observed applications.

Influence of Capping Agents on Optical Properties, Dispersion Behavior and Morphology of Nanostructured ZnO

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In this paper, nanostructured ZnO was synthesized via a simple, cost-effective and environment-friendly modified wet chemical process at room temperature and explored the effects of cationic, anionic, and non-ionic surfactants on the optical properties, dispersion behaviour, and morphology on ZnO nanoparticles (NPs).

For the synthesis of ZnO NPs, $Zn(Ac)_2 \cdot 2H_2O$ was precipitated with NaOH, in water and methanol as a reaction medium producing ZnO NPs named **ZnO-W** and **ZnO-M** respectively. ZnO-W was then capped with cationic (ethylenediaminetetraacetic acid), anionic (cetyltrimethylammonium bromide), and non-ionic (polyvinylpyrrolidone) surfactants, resulting in **ZnO-CTAB, ZnO-EDTA, and ZnO-PVP NPs** respectively.

Different characterization techniques like XRD, HRTEM, FESEM, UV-visible, FTIR, and DLS-Zeta Potential were used to ensure the purity, crystallinity and stability of prepared samples. XRD pattern showed that each sample was formed in a single phase and indicated good crystallinity of the prepared particles with an average Scherrer size of ~20.314±0.01 nm. The morphology of prepared NPs was examined under HRTEM, in which ZnO-W, ZnO-PVP, ZnO-CTAB and ZnO-M showed rod-like structures, while ZnO-EDTA interestingly, showed star or flower shape structures, all having a diameter of ~21 nm. The UV-visible absorption peak for NPs was observed between 362-370 nm, with a band gap energy of ~3.33 eV. The absorption peaks and band gap energies of ZnO-CTAB, ZnO-EDTA and ZnO-PVP varied due to the presence of surfactants. Nanoparticles' stability and agglomeration behaviour were investigated using zeta potential (ζ) studies through dynamic light scattering (DLS). ζ value increased from -13.22mV for ZnO-W to -24.31mV for ZnO-PVP, indicating an increase in stability of the NPs likely due to charge neutralisation which was discussed in detail.

Optimizing Soil-Cement Stabilization for Subgrade Improvement: An Experimental Study

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Recent years have seen a significant increase in both natural and man-made disasters, posing severe risks to human lives, infrastructure, and the environment. Soil cement stabilization has emerged as a viable solution to enhance the resilience of critical infrastructure systems against these threats. This study investigates the effectiveness of soil-cement stabilization in mitigating the impact of catastrophic events, including earthquakes, hurricanes, floods, wildfires, and man-made disasters such as industrial accidents and cyber-attacks. By improving soil stability and reinforcing critical infrastructure components, soil-cement stabilization can significantly reduce the risk of structural damage and collapse.

The research focuses on several key objectives: assessing the compressive strength of soil-cement mixtures, optimizing cement content for desired strength, understanding load-bearing capacity, and evaluating stress resistance under varying conditions. The study also explores the application of soil-cement stabilization in site-specific contexts, emphasizing its role in subgrade improvement, liquefaction mitigation, and the enhancement of shear strength through the incorporation of fly ash.

A comprehensive experimental setup was designed to evaluate the properties of soil-cement mixtures. Soil samples were collected, prepared, and mixed with varying percentages of cement. The mixtures were subjected to a series of tests, including the Modified Proctor Test, Unconfined Compression Test, and Shear Strength Test, to determine optimal moisture content, maximum dry density, and overall performance. The results were analyzed to identify the most effective mix design for ground improvement applications. The findings highlight the potential of soil-cement stabilization to enhance infrastructure resilience, providing a robust method for disaster mitigation and recovery. By incorporating soil-cement stabilization techniques into disaster response plans and infrastructure restoration efforts, communities can better withstand the impacts of both natural and man-made catastrophic events, ultimately fostering greater resilience and sustainability.

Environmentally Conscious Pavement Solutions: The Role of Coconut Biochar and Linseed Oil in Asphalt Binder Modification

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The quality of asphalt binders significantly influences the performance of asphalt mixtures and pavements, especially under varying temperature and traffic conditions. However, conventional petroleum-based asphalt binders are prone to high-temperature deformation, aging, and environmental concerns. To address these limitations, numerous modifiers have been employed to enhance the functionality and durability of asphalt binders. Recently, biobased modifiers have garnered significant attention as sustainable alternatives to conventional binders, reducing reliance on non-renewable resources.

ut biochar (CB) and linseed oil (LO) on the physical properties of asphalt binders were investigated. A user-defined experimental design with 16 trials was adopted, incorporating CB at 0%, 5%, 10%, and 15%, and LO at 0%, 1%, 2%, and 3%. Response surface methodology (RSM) was then used to develop predictive models for the softening point and viscosity of both unmodified and modified binders.

The addition of CB and LO significantly improved the consistency of the binders, as demonstrated by notable increases in softening point and viscosity. Furthermore, RSM analysis revealed that the percentages of CB and LO have a statistically significant effect on both properties at a 95% confidence level. The predictive models exhibited high accuracy, with R^2 values exceeding 0.97, indicating strong agreement between experimental results and model outputs. Multi-objective optimization identified 15% CB and 2.4% LO as the optimal concentrations to achieve the desired binder consistency. Overall, this study underlines the efficacy of biobased materials in enhancing asphalt binder performance, offering a promising avenue for more sustainable and environmentally responsible pavement engineering.

Next-Generation Techniques for Reservoir Sedimentation Assessment and Forecasting

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Reservoirs store water for human consumption, irrigation, power production, navigation, flood, and draught mitigation to ensure society's health and wealth. Sedimentation is an unfavourable phenomenon that hinders all types of reservoir operation and life. Reservoir Sedimentation is unsteady and nonuniform, making it difficult to measure and model adequately.

The research aims to formulate a novel methodology to evaluate the sedimentation, deposition, and its future impact on the capacity of any reservoir in minimal time. Moreover, this is the first attempt to integrate remote sensing results with ANN for evaluating and forecasting the live storage of a reservoir.

This research analyzed sedimentation in the Sarni reservoir using LISS-3 satellite data. Multispectral temporal data were utilized to extract the water spread area of the reservoir at corresponding water levels. The active storage capacity of the reservoir between the highest and lowest observed level during the study period (2017-2019), was evaluated using the Trapezoidal formula. The analysis results revealed that 37.801 MCM of reservoir capacity has been depleted due to sediment deposition in the last 52 years (from 1967 to 2019) i.e. almost 34.25 % part of its storage volume. The yearly rate of sedimentation in the reservoir is 0.724 MCM or 0.66%. The Sarni reservoir was originally constructed as a lake type in 1967, but it transitioned to a flood plain-foot hill type in 2019 due to continuous sediment deposition on the reservoir bed. From the neural network fitting, the future storage capacity projection of the Sarni reservoir was carried out for the year 2071.

Experimental Investigation of Entrainment and Deposition in Granular Flows Using a Flume Setup

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Understanding entrainment in granular flows is crucial for predicting sediment transport and deposition dynamics. This study investigates the effects of varying coarse-grained fractions and water content (w/c) on flow behavior using a small-scale flume setup. The research aims to bridge the gap between controlled laboratory studies and real-world sediment transport processes.

A total of 32 flume experiments were conducted, systematically varying stony fractions (0-20%) and w/c (20-50%). The flume included smooth and rough depositional beds to analyze their impact on runout distances, deposition thickness, and lobe morphology. High-resolution digital elevation models (DEMs) were generated for post-experiment analysis. Flow velocities, shear rates, and deposit structures were quantified using LiDAR scanning and direct measurements.

Results showed that entrainment was primarily governed by shear and collisional forces, with higher w/c enhancing runout but reducing deposit thickness. Rough beds promoted levee formation, while smooth beds led to widespread deposition. Flow mobility ranged from 2.5 to 4.5, influenced by stony fractions and bed type. Dimensionless parameters such as Bagnold and Savage numbers confirmed the dominance of collisional forces over frictional and viscous stresses. This study provides valuable insights into sediment transport and depositional processes, applicable to erosion control and hazard mitigation strategies.

Experiment Study of High Performance Concrete Designed using Industrial Waste for Durability

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The purpose of this experimental study is to look at how fly ash and silica fume affect the production of high-performance concrete. The primary goal is to determine how various quantities of fly ash and silica fume affect the overall performance of concrete in terms of strength and durability. Various concrete mixes are created by partially substituting cement with fly ash at 8%, 16%, and 21%, and silica fume at 4%, 5%, and 7%.

To improve the workability of the concrete mixtures, a superplasticizer is added at a consistent rate of 1.5% by weight of cement in all specimens. The concrete mixes are designed to reach three different strength grades: M70, M80, and M90, with mix designs specific to each grade. The objective of this research is to understand how these added cementitious ingredients, when combined with the superplasticizer, affect both the fresh and hardened properties of the concrete. A set of durability and mechanical tests are run to assess the concrete's performance under various conditions. These include the carbonation test, which assesses the concrete's susceptibility to carbonation, a process that can result in reinforcement corrosion and lower durability. The water absorption test is used to determine the permeability of the concrete, which is important for determining its resistance to environmental conditions such freeze-thaw cycles, chemical attack, and moisture infiltration.

The study also includes key strength tests, such as compressive strength, which is critical for determining the concrete's resistance to axial loading; flexural strength, which measures the concrete's ability to resist bending; and split tensile strength, which evaluates the concrete's ability to resist tension and cracking. These studies offer insight into the structural integrity and long-term performance of concrete constructed from various mixtures of fly ash and silica fume.

The study intends to determine the best fly ash and silica fume combination to increase the strength and durability of high-performance concrete by analyzing the test results. This could have advantages for a range of construction applications, especially those that call for materials with high strength and durability. The results will advance knowledge of the efficient use of supplementary cementitious materials in concrete design to satisfy the exacting specifications of contemporary infrastructure projects.

Behaviour of Self-Compacting Self-Healing Concrete (SH-SCC) for Crack Healing and Durability Assessment

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The evaluation of self-healing processes in self-compacting concrete (SCC) is the primary objective of this study, which also aims to examine the durability and crack-sealing performance of SCC under different conditions. Self-healing chemicals are added to SCC to test the concrete's capacity to repair fractures on its own, which results in longer lifespan and less maintenance. There are some Objective on which study focuses as To evaluate SH-SCC's self-healing performance and cracking behaviour; To assess how well mechanical characteristics, such strength and stiffness, return during the healing process; To examine SH-SCC's resistance to environmental factors and cyclic loading; To maximize flow ability and healing performance by improving the SH-SCC mix design.

Ordinary Portland Cement (OPC), fine and coarse aggregates, ground granulated blast furnace slag (GGBS), and healing agents such bacteria (Bacillus Subtilus) are all used in this study. Mixtures of SH-SCC are made using different amounts of healing agents. Hardened characteristics (compressive strength, flexural strength, water absorption), new properties (slump flow, T50, V-funnel), and electronic microscopy for studying the healing of crack occurrences are all assessed. Concrete samples that have already developed fractures are subjected to environmental factors and water curing. To evaluate the effectiveness of self-healing, permeability tests and optical microscopy are used to track the reduction in crack width.

SH-SCC lowers maintenance requirements, improving durability. The proportion of healing agent focused and the curing conditions affect healing performance. SH-SCC improves environmentally friendly building practices, lowers maintenance costs, and increases structural durability. Long-term performance under various climatic conditions, large-scale applications, and most effective healing agents can all be studied in future studies. Various self-healing agents, including bacteria-based and crystalline admixtures, were incorporated into the mix design. The experimental results demonstrated significant improvements in crack healing and durability, making SH-SCC a promising material for sustainable infrastructure.

Analysis of Travel Mode Choice Behavior between Commuters and Non-Commuters in Bhopal: A Value of Time Study

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Understanding how different groups value travel time is crucial for optimizing transportation infrastructure and policy, particularly in rapidly growing cities like Bhopal, Madhya Pradesh. This study aims to analyze and compare how commuters and non-commuters in Bhopal value their travel time across different transportation modes, including public buses, auto-rickshaws, private vehicles, and shared mobility options. With Bhopal's unique characteristics as a planned city experiencing rapid urbanization and a growing public transportation network, understanding these behavioral patterns can help address increasing congestion and improve transportation efficiency while promoting sustainable mobility solutions.

The research methodology employs an orthogonal experimental design to develop a Stated Preference (SP) survey, gathering data from 425 respondents across Bhopal's major residential and commercial areas. The study utilizes a multinomial logit model based on random utility maximization theory to analyze travel mode choices. The model incorporates key variables including travel time, cost, and mode-specific characteristics for five primary transportation modes available in Bhopal: city buses, auto-rickshaws, private cars, shared electric vehicles, and shared bicycles.

The findings reveal that commuters in Bhopal generally place a higher value on travel time compared to non-commuters, with the exception of private car users. Auto-rickshaw users exhibit the highest value of travel time (₹41.5/hour for commuters), followed by private car users (₹34.2/hour). The study also shows that public transportation remains the preferred choice despite longer travel times, with a 38.2% selection probability, reflecting Bhopal's socioeconomic dynamics and recent investments in BRTS (Bus Rapid Transit System). These insights can inform evidence-based transportation policy decisions, particularly in developing integrated mobility solutions that balance time efficiency with affordability and sustainability in rapidly growing urban centers like Bhopal.

Solar-based Thermo-mechanical Treatment for Commercially Viable Management of Unsorted C&D Wastes

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Unsorted construction and demolition (C&D) waste is a major bottleneck towards the use of recycled aggregates. A lack of systematic dismantling results in unsorted C&D waste, which on crushing results in mixed recycled aggregate (MRA). MRA shows poor performance in concrete and limited field applications. The present study develops a solar-based thermo-mechanical treatment for improving the performance of MRA and the overall commercial viability of managing unsorted C&D wastes.

MRA was collected from the local recycling plant. Six sets of MRA were heated to elevated temperatures of 300 °C – 800 °C, followed by mechanical abrasion. Treated MRA was evaluated for aggregate characteristics. The optimal set of treated aggregates, MRA-700, was used for casting concrete and compared with untreated MRA and natural aggregates. Thermo-mechanical was also evaluated for environmental and economic costs.

The study shows that thermo-mechanical treatment results in the loss of adhered mortar and improves aggregate characteristics. The treatment protocol of 700 °C, MRA-700, shows the best aggregate characteristics and satisfies the codal provisions as per IS 383: 2016. In concrete, MRA-700 shows higher workability (166.67%) and similar mechanical strength, i.e., compressive (93.72%), flexural (99.94%) and split tensile (97.87%). Assessment of the treatment procedure shows that solar-based thermo-mechanically treated MRA will have lower costs and carbon emissions as compared to natural aggregates. A solar-based commercial-scale model is also developed for the proposed thermo-mechanical treatment. The present study shows that thermo-mechanically treatment of MRA can be a sustainable alternative to natural aggregates. The proposed treatment plant can be integrated with existing recycling facilities to effectively manage the unsorted C&D wastes in the Indian construction industry.

Enhancing Erosion Resistance of Narmada River Sand Using Fiber-Reinforced Microbial-Induced Calcite Precipitation (MICP)

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Microbial-induced calcite precipitation (MICP) has emerged as a sustainable and eco-friendly ground improvement technique. However, the erosion resistance of MICP-treated samples under wetting-drying (WD) cycles remains a critical concern. This study investigates the effects of carbon, basalt, and polypropylene fiber reinforcements on the erosion resistance of biotreated Narmada River sand subjected to wetting-drying (WD) cycles.

The sand was oven-dried at 105°C, sieved, and mixed with fibers at 0.20%, 0.40%, and 0.60% by soil weight, with a standardized fiber length of 6 mm. *Sporosarcina pasteurii* was cultivated and applied with a 0.5 M cementation solution to induce MICP. Biotreatment was conducted for 9 and 18 days to enhance calcite precipitation, which was characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS). The samples were subjected to 5, 10, and 15 WD cycles to simulate riverbank conditions. Erosion resistance was assessed by measuring mass loss, unconfined compressive strength (UCS), split tensile strength (STS), and ultrasonic pulse velocity (UPV).

This study presents an eco-friendly soil stabilization method using fiber-reinforced microbial-induced calcite precipitation (MICP) for erosion-prone Narmada River sand. Optimal fiber contents (0.40% for carbon and basalt, 0.20% for polypropylene) were identified to enhance erosion resistance under wetting-drying (WD) cycles simulating riverbank conditions. Basalt fibers showed the best performance, with only 3.53% mass loss after 15 WD cycles. Extending biotreatment from 9 to 18 days improved unconfined compressive strength (UCS), split tensile strength (STS), and ultrasonic pulse velocity (UPV). This sustainable approach reduces brittleness, promotes uniform calcite distribution, and offers a scalable solution for erosion control, minimizing ecological impact than traditional methods.

Hybrid Multi-Scale Residual CNN-LSTM Framework with Wavelet Transform for Predicting Crude Oil Futures Prices

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Accurately predicting crude oil futures prices is crucial for stakeholders due to its significant economic and strategic importance. The highly volatile, nonlinear, and stochastic nature of crude oil price data poses considerable challenges to traditional prediction models. This study aims to overcome these limitations by proposing an innovative hybrid framework that combines Wavelet Transform (WT), Multi-Scale Residual Convolutional Neural Networks (MRC-CNN), and Long Short-Term Memory (LSTM) networks. This approach captures both short-term fluctuations and long-term trends, making it suitable for complex financial time series.

The proposed WT-MRC-LSTM model employs the Discrete Wavelet Transform to decompose price data into multiple frequency components, allowing detailed multiscale analysis. The Multi-Scale Residual CNN module extracts spatial features using convolutional kernels of varying sizes, while its residual connections address gradient degradation in deep architectures. The LSTM layer captures temporal dependencies and sequential patterns, further enhancing prediction accuracy. Historical crude oil futures price data, enriched with technical indicators such as moving averages, oscillators, and pivot points, was used for training and validation. Preprocessing steps included handling missing values, normalization, and feature selection via XGBoost.

Empirical results highlight the model's superior performance, achieving lower Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) alongside higher R^2 scores compared to benchmark models, including ANN, CNN, LSTM, and CNN-LSTM. Robustness tests on weekly and monthly datasets confirmed its adaptability across different temporal resolutions. This study underscores the significance of integrating wavelet transform with hybrid deep learning models for improved forecasting. The proposed framework not only enhances predictive accuracy but also offers a robust tool for analyzing financial time series, with potential applications in other markets. Future work could explore alternative signal decomposition techniques and extend the framework for real-time trading scenarios.

Developing a Novel Load Balancing Approach for Mitigating Resource Contention in Multi-Cloud Environments

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Effective load balancing is a critical challenge in multi-cloud environments due to the dynamic and distributed nature of resources. Resource contention, a significant bottleneck, often leads to degraded performance and higher operational costs. This study aims to develop a novel load-balancing approach to mitigate resource contention, ensuring optimal utilization and scalability in multi-cloud infrastructures.

The proposed methodology employs a hybrid framework integrating heuristic and machine-learning techniques for real-time resource allocation. The approach dynamically predicts workload trends using historical data and employs a ranking system for resource evaluation. Experiments were conducted using CloudAnalyst to simulate diverse multi-cloud scenarios, evaluating parameters like response time, throughput, and cost efficiency. The Clonal Selection Algorithm (CSA) was utilized to enhance resource optimization under high-demand conditions.

Results indicate that the proposed approach significantly reduces resource contention, achieving up to 30% improvement in response time and 25% better load distribution compared to existing strategies. The framework demonstrated robustness in handling complex multi-cloud environments while maintaining high reliability and scalability. These findings highlight the importance of intelligent load-balancing mechanisms for efficient cloud resource management, contributing to advancements in cloud computing research.

A Deep Learning Model for Contextual Classification of Satellite Images Employing Self-Attention Based Vision Transformers

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Space and satellite technology is witnessing an unforeseen growth due to several critical applications such as remote sensing, weather forecasting, disaster management, defense and military surveillance to name a few. Extensive research in being carried out to leverage satellite imagery for early identification of natural disasters such as massive wild fires and tsunamis. Additionally, satellite images are also being extensively used in military applications for early identification of initial stage changes in topographic features for border security, surveillance, and early threats. Such terrain changes are often observed while building hidden tunnels, airstrips and camouflaged temporary or permanent structures, specifically from a defense surveillance point of view. This paper presents a deep learning model which can identify natural disasters such as wildfires and tsunamis, along with man made structures such as air-strips. The model is also tested on more generic satellite images such as buildings, water bodies and air planes. The model first employs image filtering and contrast enhancement to remove effects of baseline noise, typically found in grainy satellite images followed by training a deep learning model. A self-attention based vision transformer model is developed in this paper so as to utilize the long-range spatial dependencies in satellite images. The vision transformer model is fine tuned with annotated contextual data. The model's performance is evaluated in terms of the accuracy, sensitivity, recall and F-measure indices. A comparative analysis with existing models clearly indicates the improved performance of the proposed model on benchmark datasets such as the Canada Wildfire Dataset, RSOD, LEMO and BigEarthNet datasets.

Cybersecurity for IoT: Design and Implementation of an Ensemble IDS

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The Internet of Things (IoT) is increasingly susceptible to sophisticated cyber threats due to inherent device vulnerabilities, necessitating the development of advanced intrusion detection systems (IDS). This study proposes the Combined Leading Ensemble Decision Classifier Module (CLEDCM), an ensemble-based framework leveraging LightGBM, Random Forest, XGBoost, and CatBoost to enhance detection accuracy and mitigate false positives. The objective is to fortify IoT network security and improve threat detection efficiency.

Utilizing benchmark datasets—NSL-KDD, UNSW-NB15, and NF-BOT-IOT—the study incorporates advanced data preprocessing techniques, including feature selection via Random Forest. The CLEDCM framework synthesizes predictions from four classifiers to create an optimized ensemble model. Experiments employed an 80:20 train-test split, with model performance rigorously evaluated using metrics such as accuracy, precision, recall, and F1 score. CLEDCM demonstrated superior performance, achieving accuracy levels of 99.94% for NSL-KDD, 95.99% for UNSW-NB15, and 83.13% for NF-BOT-IOT datasets, along with 100% binary classification accuracy. The framework effectively minimized false positives and negatives, showcasing its robustness and adaptability. These findings underscore CLEDCM's potential as a scalable, reliable solution for enhancing IoT cybersecurity, addressing dynamic threat landscapes, and ensuring data integrity.

An Intelligent Hybrid Model for Workflow Scheduling using GNN and Reinforcement Learning in Cloud Computing

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Cloud workflow scheduling is crucial for optimizing the execution of complex workflows in cloud environments. Traditional scheduling techniques often struggle to balance trade-offs between resource utilization, task execution time, and cost, particularly when workflows are represented as Directed Acyclic Graphs (DAG). This research introduces a hybrid model that combines Graph Neural Networks (GNN) with Q-learning to enhance workflow scheduling. The proposed approach aims to minimize makespan and improve overall performance while ensuring efficient resource allocation in cloud computing systems.

In this study, GNN is employed to extract rich structural information from DAG representing cloud workflows. The extracted features serve as immediate rewards for a Q-learning-based decision-making model that determines optimal task-to-resource mappings. The Q-learning agent is trained to maximize a reward function that accounts for inter-task communication time and generates a prioritized task queue for efficient resource mapping. The proposed model was implemented and tested in a simulated cloud environment using scientific workflows such as *Montage*, *Cybershake* and *SIPHT*. Comparative experiments were conducted against baseline algorithms, including ALAP, CPOP and PETS, to validate the effectiveness of the approach.

The results demonstrated significant advancements in key performance metrics, particularly for the *SIPHT* workflow. These included an 8.41% reduction in makespan, a 9.52% improvement in speedup, and a 9.33% increase in efficiency compared to traditional heuristic-based methods. The integration of GNN enabled better generalization across diverse workflow structures and facilitated the generation of reward values for individual tasks. Simultaneously, the Q-learning agent ensured the creation of an optimized task priority queue for effective mapping to resources. This study emphasizes machine learning for workflow scheduling, paving the way for scalable cloud services.

Facial Emotion Recognition Through Deep Learning

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One of the most challenging and potent research tasks in social communication is the identification of human emotions from images. Deep learning (DL) based emotion detection gives performance better than traditional methods with image processing. This paper presents the design of an artificial intelligence (AI) system capable of emotion detection through facial expressions. It talks about the emotion detection process, which consists of three primary steps: emotion categorization, face identification, and feature extraction. This study suggested a deep learning architecture for visual emotion identification based on convolutional neural networks (CNNs). Two datasets—the Japaness Female Facial Emotion (JAFFE) and the Facial Emotion Recognition Challenge (FERC-2013)—are used to assess the effectiveness of the suggested approach. The suggested model's accuracy for the FERC-2013 and JAFFE datasets is 70.14 and 98.65 percent, respectively.

A Decade of Stock Market Trends: Predictive Modeling with CNN-BiLSTM Approach

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Predicting financial market trends is challenging due to the nonlinear and time-dependent nature of financial data, influenced by dynamic factors. Traditional models like ARIMA and GARCH struggle with non-stationarity in financial time series. This study proposes a novel hybrid CNN-BiLSTM model to enhance stock price prediction by capturing spatial and temporal dependencies.
The model is trained on stock price data from 25 companies listed on the National Stock Exchange of India (NSEI) over a 10-year period (January 1, 2014 – December 31, 2023), sourced from Yahoo Finance. By incorporating technical indicators as part of feature engineering, the model improves predictive performance, particularly in volatile market conditions.

The proposed hybrid CNN-BiLSTM model effectively captures spatial and temporal dependencies, addressing the complexities of stock price prediction. Notably, the dataset includes the COVID-19 crisis, a period of heightened market volatility, allowing the model to be evaluated in adverse conditions. By leveraging CNN’s ability to extract spatial patterns and BiLSTM’s strength in modeling long-term dependencies, the model significantly enhances predictive accuracy, achieving a high accuracy rate of 97.021%. The effectiveness of the model is demonstrated through benchmarking against traditional CNN, LSTM, and ARIMA models, evaluated using key financial performance metrics such as the Sharpe Ratio and Maximum Drawdown. Results indicate that the hybrid approach outperforms conventional methods, showcasing its robustness and reliability in financial forecasting. The integration of technical indicators further improves prediction quality, making the proposed model a promising tool for portfolio management and investment decision-making in dynamic and uncertain market environments.

Indic-ST: A Large-scale Multilingual Corpus for Low-Resource Speech-to-Text Translation

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Indic-ST is a large-scale multilingual speech-to-text translation (ST) corpus curated for 15 low-resource Indic languages. It addresses gaps in ST resources for underrepresented Indic languages. Current ST systems often excel in high-resource languages but struggle with low-resource languages, especially Indic, highlighting the need for tailored datasets and models to bridge linguistic barriers. By leveraging a 6,800-hour Indic-ST dataset and techniques like domain-specific learning, this study addresses performance gaps in English-to-Indic ST while establishing robust baselines for cascade, end-to-end, and multilingual models.

The dataset includes the 6,800-hour English speech and parallel Indic text across 15 languages, sourced from news, education, conversation and religious texts. Methods involve data preprocessing, cross-lingual text alignment, and forced alignment along with automatic and human validation. Experiments evaluate cascade, end-to-end, and multilingual ST models using metrics like SacreBLEU, BERTScore, and chrF for performance analysis.

Cascade models outperform end-to-end systems on smaller datasets, while end-to-end models require extensive data for competitive results. Larger datasets, like Indic-ST, improve translation quality, with metrics like SacreBLEU, BERTScore, and chrF revealing variations in performance across languages due to factors like number of tokens, morphology, and domain-specific variability. The dataset demonstrates that language structure, domain diversity, and speaker variability significantly influence ST performance. Indic-ST highlights challenges in tokenization, morphology, and linguistic alignment for low-resource languages, emphasizing the importance of tailored datasets. Multilingual ST models show promising results but require optimized techniques to address unique characteristics of Indic languages. Indic-ST bridges critical gaps in low-resource language research, supporting ST, ASR, and MT advancements. It provides a foundation for scalable, real-time solutions in multilingual communication, fostering inclusivity for speakers of underrepresented languages while contributing to the development of robust linguistic models.

Forecasting Excellence: A Hybrid Approach for Predicting Student Performance in Higher Education

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Several transformation have been made in teaching-learning process due to the incorporation of blended learning models in higher education, which combine traditional classroom approaches with online educational resources. Finding valuable insights from educational datasets and enhancing the learning process are two benefits of analysing student learning patterns. These trends will be useful in predicting students' success, highlighting sections of the course or subject that require revision, and identifying students who require additional attention.

This study analyze and forecast student performance in higher education through the implementation of a hybrid machine-learning approach. This study uses dataset of MTech and MCA students. First, it implements cluster analysis, infer cluster labels, and apply hybrid classifiers. Through the use of several machine learning techniques, such as ensemble methods, this study hopes to improve performance forecasts over time relative to single algorithms. There are several features were used that includes academic records, online activity logs, and discussion forum posts and views.

The findings show that hybrid techniques can predict student performance much better than traditional models. For PG-1 dataset RF and LR hybrid model give 94.7% accuracy. The stacking mechanism applies with LR(Logistic Regression), DT(Decision Tree), and NB(Naïve Bayes) classifiers where LR is taken as meta classifiers. It yields 85.71 %. The voting mechanism has been applied with 3 hybrid models. The first hybrid model is RF and LR which yield 80.95% accuracy, the second is DT, SVM, and KNN which yield 88.88% accuracy, the third is NB and LR which yield 87.30 % accuracy for PG-2 dataset. This study also proposed a framework for a dashboard that incorporate overall analysis of student performance through classification, clustering, and hybrid models.

Multi-robot Searching with Limited Sensing Range for

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We consider the problem of searching for an intruder (for both static and mobile) in a geometric domain by utilizing multiple search robots. The domain is a simply connected orthogonal polygon with edges parallel to the cartesian coordinate axes. Each robot has a limited sensing capability.

We devised a comb structure to establish the hardness of the problem. Given the intractability, we propose efficient and robust algorithms, namely methods based on space-filling curves (SFC), random search (RS), and cooperative random search (CRS). Moreover, for each algorithm, we evaluate the trade-off between the number of search robots and the time required to complete the search process while considering the geometric properties of the connected orthogonal search area via Monte Carlo simulation experiments.

It turns out that the problem of finding an intruder in a grid graph is NP-hard, even for a stationary intruder. We observed that the RS and CRS methods are effective even with a minimal number of search robots; however, they need longer search time. The SFC methods provide solutions close to the baseline. However, it requires a minimum number of robots equal to the decomposed number of rectangular regions in the search region. In most scenarios, finding a moving intruder via RS and CRS approaches is quicker. In contrast, finding a static intruder via Baseline and SFC approaches is quicker. Also, we conclude that geometric properties like β (the number of spikes in the comb structure) and area can severely affect the search time and number of robots. In contrast, in other cases, for instance, the shapes with the same geometric properties do not affect the search significantly.

Mitigating Nonlinear Hardware Impairments in THz Links Using Deep Learning

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Terahertz (THz) wireless communication has emerged as a promising technology to accommodate the increasing demand for high-bandwidth services. However, the propagation of THz waves through the atmosphere is significantly affected by various factors, including attenuation, water vapor absorption, weather conditions, turbulence, rain, and beam misalignment. Additionally, the performance of THz communication links is severely degraded by non-linear hardware impairments introduced by power amplifier (PA), which distort the transmitted signal and lead to increased bit error rates (BER). Conventional estimation techniques, such as zero-forcing (ZF) and minimum mean squared error (MMSE), exhibit limitations in effectively mitigating the effects of beam misalignment, rain attenuation, and PA-induced non-linearity. Furthermore, traditional sparse signal processing approaches, such as orthogonal matching pursuit (OMP), are unable to adapt to dynamic channel conditions and complex signal distortions. To address these challenges, this paper proposes a deep neural network (DNN)-based receiver for THz communication systems, specifically designed to operate in the presence of PA non-linearity. The proposed deep learning (DL)-based receiver leverages data-driven optimization techniques to improve detection accuracy and compensate for non-linear distortions. Simulation results evaluating the BER performance under non-linear distortion caused by power amplifiers demonstrate that the proposed receiver outperforms conventional ZF, MMSE, and OMP-based receivers. The findings indicate that the DL-based receiver exhibits superior BER performance and enhanced robustness, making it a viable solution for next-generation THz communication systems.

EDenseNetViT: Leveraging Ensemble Vision Transform Integrated Transfer Learning for Advanced Differentiation and Severity Scoring of Tuberculosis

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Lung infections such as tuberculosis (TB), covid-19 and pneumonia share similar symptoms, making early differentiation challenging with X-ray imaging. This can delay correct treatment and increase disease transmission. The study focuses on extracting hybrid features using multiple techniques to effectively distinguish between TB and other lung infections, proposing several methods for early detection and differentiation. To better diagnosis of tuberculosis, the paper presented an ensemble DenseNet with vision transformer network (EDenseNetViT). The proposed EDenseNetViT is ensemble model of Densenet201 and vision transformer network that will enhance the detection performance of tuberculosis with other lung infections such as pneumonia and covid-19. Additionally, the EDenseNetViT is extended to predict the severity level of tuberculosis. For this severity score approach based on combined weighted low-level features and high-level features to show the severity level of tuberculosis as mild, moderate, severe and fatal. The study tested seven baseline models for lung infection differentiation. Initially, DenseNet transfer learning models, including DenseNet121, DenseNet169, and DenseNet201, were assessed, with DenseNet201 performing the best. Subsequently, DenseNet201 was combined with Principal component analysis (PCA) and various classifiers, with the combination of PCA and random forest classifier proving most effective. However, the EDenseNetViT model surpassed all, achieving approximately 99% accuracy in detecting tuberculosis and distinguishing it from other lung infections like pneumonia and covid-19. Compared to other top-tier models, EDenseNetViT performed the best.

Unravelling Hydroclimatic Non-Stationarity and Flood Dynamics in a Central Indian River Basin

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Understanding hydroclimatic variability, non-stationarity (NS) in hydroclimatic extremes, and their impact on flood frequency analysis (FFA) is essential for effective water resource management. With global warming, climate change, and human interventions altering hydrological processes, the fundamental assumption of stationarity is increasingly being challenged. Consequently, ignoring NS can lead to inaccurate predictions and unreliable flood estimates. This study investigates NS in hydroclimatic extremes and flood behavior in the Tapi River basin in Central India. The objectives include assessing NS in hydroclimatic extremes and evaluating its impact on FFA. Additionally, the study seeks to identify the key factors influencing streamflow and examine how NS affects flood characteristics.

This study employs daily hydroclimatic data from 1973 to 2021, applying statistical trend tests, change-point detection, and a non-overlapping block-stratified random sampling approach to evaluate stationarity. Imperfect Attribution Analysis is utilized to determine climate drivers influencing streamflow variations. Annual Maximum Series and Peaks-Over-Threshold methods are compared for flood analysis to assess flood frequency distributions. Additionally, copula-based bivariate modelling is applied to examine dependencies among key flood characteristics (viz., peak, volume, and duration), providing comprehensive insights into flood dynamics under changing climatic conditions. Finally, the study compares univariate and bivariate flood characteristics while accounting for NS influences.

This study investigates NS in hydroclimatic extremes and flood behavior in the Tapi River basin in Central India which originates near Multai in the Betul District of Madhya Pradesh. Results indicate significant NS in rainfall and temperature extremes, while streamflow remains relatively stable. Further, Annual Maximum Series (AMS) and Peaks-Over-Threshold (POT) methods exhibit distinct flood frequency patterns, with AMS yielding higher frequency estimates in low-flow regions and POT outperforming AMS in high-flow areas. Bivariate analysis using copula reveals strong peak-volume correlations in AMS, whereas POT provides better volume-duration and peak-duration dependencies. The Gumbel and Clayton copulas emerge as the best-fit models for characterizing flood dependencies. These findings enhance the understanding of hydroclimatic non-stationarity, aiding in developing more resilient flood management strategies for the Tapi River basin.

Geochemistry and Petrogenesis of Tonalite Trondhjemite Granodiorite Gneisses of Babina Area, District Jhansi, Uttar Pradesh

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Archean tonalite-trondhjemite-granodiorite (TTG) gneisses are known worldwide for their role in the formation of the early earth's crust and their association with subduction settings. The present study is focused on the geochemistry and petrogenesis of TTG gneisses of the Bundelkhand craton exposed in the Babina area, which is closely associated with the central Greenstone belt.

Field study, petrography, and geochemistry of TTG gneisses were carried out to understand the source, origin, petrogenesis, and tectonic history and propose a model for TTG gneisses. The present geochemical data was plotted with published data to compare and better understand the geochemical behaviour of the rocks.

TTGs have high silica (72.26 to 58.17 wt %) low K_2O (0.99 to 3.33 wt %) and Na_2O (1.29 to 0.93 wt %). Geochemistry suggests TTG gneisses are meta–meta-peraluminous and are believed to derive from the melt generated from hydrous partial melting of low K mafic rocks and mantle melts in the plagioclase stability field with hornblende in residue followed by fractionation of plagioclase, biotite along with accessory minerals including, epidote, allanite, Fe-Ti oxide etc. Negative anomaly in Nb, Sr, P and Ti and positive anomaly in Pb suggesting subduction related magma generation with or without crustal contamination. The REE data of TTGs shows with pronounced negative Europium anomaly suggesting early fractionation of plagioclase from the melt. Further enrichment in LREE relative to HREE in the TTG gneisses suggests magma is of crustal origin with significant contribution from subducted oceanic or arc-related processes. Comparing the present study with published data after Malviya et al., (2022) suggests that the TTGs of Babina area are of two types (1) TTG-II which is generated by the hydrous partial melting of slab melting of mafic crust with some crustal contamination and emplaced around 3.3-3.2 Ga, (2) TTG-III which is generated at greater depth than TTG-II by partial melting of pre-existing crust including TTG-I and TTG-II and emplaced around ~2.7 Ga.

Quantifying Space Weather Effects on the Ionosphere During the Ascending Phase of the 25th solar cycle

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The ionosphere, a highly dynamic region of Earth's upper atmosphere extending from approximately 60 km to over 1000 km, plays a crucial role in radio wave propagation and satellite-based communication. Its electron density varies due to solar activity, geomagnetic disturbances, and atmospheric dynamics, leading to fluctuations in total electron content (TEC) and ionospheric scintillation. The ascending phase of the 25th solar cycle has exhibited increased space weather activity, significantly impacting the low-latitude ionosphere. This study aims to quantify these effects by analyzing TEC variations and scintillation characteristics, focusing on the Equatorial Ionization Anomaly (EIA) region.

To achieve this, we used a multi-instrument approach, integrating ground-based GNSS and NavIC receiver data along with space-based electron density measurements from the Swarm satellite constellation. Ground-based receivers provide TEC data and S4 index variations, which indicate scintillation intensity. Swarm satellites complement these observations by offering in-situ electron density profiles at varying altitudes. This combined dataset enables a detailed investigation of ionospheric irregularities and their evolution with solar activity and geomagnetic conditions.

Our findings reveal a clear increase in ionospheric scintillations as solar activity progresses, with the most frequent and intense events occurring during the equinoctial months. However, during geomagnetic disturbances, a suppression of scintillation activity is observed, likely due to storm-induced changes in thermospheric winds and electrodynamic processes. Simultaneous ground-space observations enhance our understanding of ionospheric dynamics, contributing to improved space weather forecasting models. These insights are essential for mitigating ionospheric effects on GNSS-based navigation and communication systems, ensuring their reliability during periods of heightened solar activity. This study provides a foundation for better predictive models and mitigation strategies to safeguard critical space-based services.

Role of Aerosol Liquid Water Content in $PM_{2.5}$ Mass Closure Analysis and Source Apportionment of $PM_{2.5}$ Chemical Species in Bhopal, Madhya Pradesh

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It is important to understand the composition and sources of $PM_{2.5}$ for an effective air pollution mitigation strategies. However, standard aerosol chemical characterization efforts do not fully explain the measured $PM_{2.5}$ mass, because oxygen, hydrogen, and other atoms present in organic carbon (OC) and those associated with geological minerals, and aerosol liquid water content (ALWC) are unmeasured. This study investigates the role of ALWC in $PM_{2.5}$ mass closure, its influence on secondary inorganic aerosol formation and source apportionment in Bhopal, Madhya Pradesh.

Twenty-four-hour time-integrated $PM_{2.5}$ samples were collected in 2019 using the Speciation Air Sampling System. Gravimetric mass and chemical speciation, including elemental composition, organic carbon, elemental carbon, and water-soluble inorganic ions, were analyzed using DRI-Carbon Analyzer, ED-XRF and Ion Chromatography respectively. ALWC was estimated based on thermodynamic equilibrium modeling to assess its contribution to total $PM_{2.5}$ mass. Positive Matrix Factorization (PMF) was applied to identify and quantify major $PM_{2.5}$ sources.

The results showed that the $PM_{2.5}$ mass closure is significantly influenced by ALWC (2.6 - 6.8 $\mu g\ m^{-3}$), strong temporal trends in ALW mass concentration highlights the significant role of major hygroscopic inorganic species, specifically sulfate, nitrate, and ammonium, in driving these trends. In Bhopal, source apportionment using PMF revealed nine key contributors, with residential heating (22.8 %) being the largest contributor. The biomass burning emissions peaked during the stubble burning period in India. Additionally, a smelter source was identified, characterized by high explained variance in EC3 (40%), Zn (71%), Pb, Cu, and EC2. The findings underscore the importance of incorporating ALWC in mass closure and source apportionment studies to improve $PM_{2.5}$ characterization. This study provides valuable insights into aerosol composition, source contributions, and the role of ALWC in $PM_{2.5}$ dynamics, aiding in more accurate air quality assessments and policy development for pollution control in Madhya Pradesh.

Unravelling the Spatio-Temporal Characteristics of Meteorological Droughts in the Upper Chambal River Basin

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Droughts are complex natural hazards characterized by prolonged periods of below-average precipitation, resulting in water shortages that significantly impact agriculture, water resources, ecosystems, and socio-economic stability. Understanding the spatio-temporal dynamics of droughts is essential for effective mitigation. This study evaluates drought characteristics in the Upper Chambal River Basin (UCB) using the Standardized Precipitation Index (SPI) across multiple timescales (SPI-1, SPI-3, SPI-6, SPI-9, SPI-12, and SPI-24) over a 52-year period (1971-2023). In addition to drought analysis, rainfall indices, including total rainfall (PRCP), rainy days (RD), consecutive dry days (CDD), and consecutive wet days (CWD), were also examined to understand broader implications of rainfall changes. The results reveal significant spatial and temporal variations in drought patterns. Short- to medium-term SPI indices show frequent drought events in the central and southern sub-catchments, particularly in Kshipra and Chambal Main, highlighting vulnerability to short-term precipitation deficits. In contrast, northern sub-catchments exhibit greater resilience to long-term droughts. The analysis revealed the presence of prolonged droughts, exceeding 40 months, particularly in the southern and central UCB, suggesting susceptibility to extended hydrological imbalances. Trends in rainfall indices show increased rainfall frequency and intensity in the central UCB. southern UCB experiences longer dry spells, while the northern UCB sees more extended wet periods. These findings emphasize the need for adaptive water management strategies, prioritizing water conservation, infrastructure, and drought-resistant agriculture to mitigate the growing risk of both droughts and extreme rainfall events in the basin.

Monitoring Riverbank Erosion and Morphological Alterations Through Remote Sensing and GIS: A Case Study of the Sone River, Umaria District

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The relentless demand for construction-grade sand in India is placing immense strain on our rivers, leading to severe environmental repercussions. Studies indicate alarming consequences such as the degradation of river systems, diminished river flows, and declining groundwater levels. The uncontrolled and aggressive extraction of sand from many of our rivers poses a grave threat to their ecosystems, potentially causing irreversible damage to both the rivers themselves and the groundwater aquifers they support. Additionally, sand mining alters the morphology of rivers, disrupting their natural flow velocity and causing unwanted meandering, which further destabilizes and disrupts the entire riverine ecosystem.

This study explores the potential of remote sensing and GIS technologies, utilizing tools such as ArcGIS 10.8, Google Earth imagery and Sentinel-2 satellite data to analyse the impact of sand mining on river morphology. The research focuses on monitoring the spatial dynamics of bank shifting along the Sone River between 2016 and 2025. The study area is centered on the Sone River basin in Umaria district, Madhya Pradesh, which spans approximately 112 kilometres within the district and serves as a significant site for sand deposition, particularly in its meandering stretches. The increasing demand for sand, driven by rapid urbanization, has intensified the unsustainable extraction of sand, posing significant challenges to the river's ecological balance and geomorphological integrity.

The study examines various scenarios of river channel profile alterations caused by sand mining activities to assess the implications of different degrees of river degradation. The findings provide up-to-date and reliable evidence on the dynamic fluvio-geomorphology of the Sone River, which is critical for the planning and implementation of effective erosion and sand mining control measures. Undertaking scientific research on the environmental impacts of sand mining on river systems is imperative for ensuring long-term sustainability and achieving a balance between socio-economic needs and environmental conservation.

Quantifying Flash Drought Threats to Biodiversity: An Integrated Risk Assessment Framework for India's Protected Areas

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Climate change is intensifying flash droughts, characterized by their rapid onset and intensification, creating hotter and drier conditions that threaten biodiversity and local communities in India. This study developed a framework to assess flash drought risk across India's Key Biodiversity Areas (KBAs) from 1979-2021. The framework evaluated three key factors: hazard (probability of flash droughts), vulnerability (susceptibility to damage), and exposure (degree of contact with flash drought conditions). The research examined how these rapid-onset droughts affect tree cover loss, wildfires, and freshwater species diversity within KBAs, while also analyzing impacts on populations and croplands. Results showed that 45.8% of KBAs fall into the high-risk category, with inland forests and national parks showing greater vulnerability. Among freshwater KBAs, 73.8% face moderate to high flash drought risk. The study found significant correlations between the risk index and trends in both tree cover loss and wildfire incidents. High-risk areas with extensive agriculture, such as the Jawaharlal Nehru Bustard Sanctuary (8,316 km^2), are particularly vulnerable. In these regions, flash droughts can cause rapid crop failure, threatening food security and local livelihoods. The research reveals the urgent need for targeted conservation strategies and policy reforms to address flash drought challenges. This framework serves as a valuable tool for prioritizing conservation efforts and developing resilient ecosystem management plans as climate-related challenges intensify. This study's findings are crucial for policymakers and conservation managers working to protect India's biodiversity hotspots and agricultural regions from the growing threat of flash droughts. The framework provides a scientific basis for implementing adaptive management strategies in vulnerable areas.

Innovative Methodology for Intensified Flash Drought Detection and its Impact on Terrestrial Ecosystem across Indian River Basins

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Flash droughts (FDs) have gathered significant attention in the recent past because of their abrupt and rapid emergence, leading to substantial consequences for water sources, ecosystems, and agriculture. The influence of FDs on society can vary depending on numerous factors like their frequency, intensification rate, and mean severity. However, these aspects are not yet well comprehended, particularly concerning India, and remain unclear. In this research, a novel method was developed to quantitatively establish the definition of FD using the Aridity Index (AI). This innovative approach was then applied to analyze the spatiotemporal features, including trends, and the factors that trigger FDs in 25 river basins throughout India from 1981 to 2021. During the study, the hydrometeorological conditions were thoroughly examined, encompassing precipitation anomalies, soil moisture percentiles, vapor pressure deficit, and temperature anomalies at different stages of flash drought. Also, we investigated FD impact on the terrestrial ecosystem. The findings indicate that FDs characterized by rapid intensification are more prevalent in humid regions as opposed to semi-arid and sub-humid regions. Moreover, the study reveals that both temperature and precipitation play crucial roles as primary triggers of FDs across a substantial portion of the research area. In specific regions, such as the Western Ghats and northeast India, the individual influences of precipitation and soil moisture act as triggers for FDs. Furthermore, atmospheric aridity can create conditions that are favorable for the occurrence of FDs. Further, a serious decrease in Water Use Efficiency (WUE) and underlying WUE is also observed over some parts of Southern India and Ganga river basin, which indicates the non-resilient nature of the ecosystem towards flash drought conditions. The findings will provide valuable insights to policymakers, enabling them to develop effective strategies to mitigate the repercussions of FDs on agriculture and water resources in India.

Spatio-Temporal Dynamics of Evolving Rainfall Patterns over Madhya Pradesh

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Rainfall and temperature are crucial climate parameters influencing global climate change. Changes in rainfall patterns lead to environmental, economic, and social consequences. This study examines the spatio-temporal evolution of rainfall across Madhya Pradesh, known as the "Mother's Home of Rivers," as its origin of major rivers like the Narmada, Tapi, Chambal, and Betwa. Six rainfall indices, annual total rainfall, number of rainy days, maximum 1-day rainfall, heavy rainfall days, and consecutive wet and dry days are analyzed using 0.25° × 0.25° gridded data from the India Meteorological Department (1951-2023). Trends are assessed through the Modified Mann-Kendall (MMK) test, which accounts for autocorrelation in time-series data, enhancing trend detection accuracy. The analysis covers both past (1951-2000) and recent (2001-2023) climates to evaluate spatio-temporal variations in rainfall patterns across the region. The results indicate a distinct positive shift in the annual total rainfall from the eastern parts of Madhya Pradesh to the western part, whereas the rainfall is prominently decreased in the northern part. The number of rainy days has declined across the region, highlighting a reduction in moderate and evenly distributed rainfall events. However short-duration, high-intensity rainfall events have become more frequent in western Madhya Pradesh, leading to concerns about extreme precipitation and its associated impacts. The modified Mann-Kendall test confirms an increasing trend in annual total rainfall in the recent period, alongside more frequent wet spells and fewer dry spells. This suggests a shift toward unseasonal rainfall patterns, which may have far-reaching consequences for the region's hydrological cycle. The observed changes in rainfall trends could significantly impact water availability, groundwater recharge, and river flow regimes. These fluctuations challenge agriculture by disrupting crop cycles, reducing yields, and impacting irrigation. Adaptive water management, efficient irrigation, and climate-resilient farming are essential to mitigate Madhya Pradesh's shifting rainfall impacts.

WS2 Functionalized Oxide Hemt for IoT Enabled Portable Pb2+ Ion Detection in Water

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The presence of lead (Pb^{2+}) ions in water poses severe health risks, especially to children, affecting behavior, cognitive development, and organ functions. To mitigate these risks, strict safety limits of 10 ppb (WHO) and 15 ppb (EPA) have been established. This work aims to develop an IoT-enabled, portable WS_2-functionalized MgZnO/CdZnO HEMT sensor for real-time monitoring of Pb^{2+} ions in water, ensuring concentrations remain within safety thresholds.

The MgZnO/CdZnO heterostructure was fabricated using a Dual Ion Beam Sputtering system, and the HEMT device was created via e-beam lithography. Hydrothermal synthesis was employed to prepare WS_2 nanostructures using CTAB as a surfactant. These WS_2 nanostructures were dropcasted onto the HEMT gate for functionalization. The sensor's electrical characterization was performed using a Keithley 4200 semiconductor parameter analyzer, followed by selectivity testing using a solution method. Finally, the sensor was integrated into a portable IoT-enabled platform for real-world deployment.

The fabricated WS_2-functionalized MgZnO/CdZnO HEMT sensor exhibited exceptional performance, with a rapid response time of <5 seconds and a detection limit of 57 ppt. The sensor demonstrated high sensitivity (738.85 µA/ppb), a recovery rate of 99.14%, and excellent reusability. Real-time tests conducted on water samples from IIT Indore and the Narmada River near Maheshwar Fort confirmed its practical applicability. This robust, portable, and IoT-enabled sensor provides a reliable solution for environmental monitoring and water quality surveillance, making it a strong candidate for addressing global waterborne toxic metal contamination challenges.

Snapshot Averaged Matrix Pencil Method (SAM) For Direction of Arrival Estimation

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Estimating the direction of electromagnetic (EM) waves from a radio source using electrically short antennas presents a significant challenge in radio astronomy. Accurate Direction of Arrival (DoA) and polarization estimation are crucial for studying celestial radio sources, especially at low frequencies. In this paper, we present a novel algorithm that enhances the accuracy of both direction and polarization estimations compared to existing methods. Our proposed approach aims to improve the performance of space-based and ground-based radio astronomy missions, particularly in environments where traditional DoA techniques face limitations.

The Snapshot Averaged Matrix Pencil Method (SAM) is a modified version of the existing Matrix Pencil Method (MPM) for DoA estimation. MPM typically estimates the DoA of incoherent EM waves using unitary transformations and the Least Square Method (LSM). Our modification, SAM, incorporates a snapshot averaging technique to enhance incoherent frequency estimation, thereby improving accuracy. This modification is specifically designed for the proposed Space Electric and Magnetic Sensor (SEAMS) mission, which aims to study the radio universe below 16 MHz. To evaluate the effectiveness of SAM, we conducted a scaled-down DoA experiment at a resonant frequency of approximately 72 MHz.

The results demonstrate that SAM significantly enhances DoA and polarization estimation accuracy upto milli-arcseconds. It successfully distinguishes between different polarization states, including Right-Hand Circular Polarization (RHCP), Right-Hand Elliptical Polarization (RHEP), Left-Hand Circular Polarization (LHCP), Left-Hand Elliptical Polarization (LHEP), and Linear Polarization (LP). These findings are critical for improving low-frequency radio astronomy observations, where precise DoA and polarization measurements are essential for studying astrophysical phenomena. The proposed SAM algorithm holds potential for future space missions and ground-based observatories, offering a more robust solution for analyzing weak and incoherent radio signals.

High-Performance Memristor-Based Flip-Flops: Comparative Evaluation with Conventional CMOS Technologies and Hardware Implementation of NOT Gate

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This paper presents a Yttria-based memristor flip-flop design and evaluates its performance against conventional CMOS flip-flops. Flip-flops are crucial in sequential circuits, playing a vital role in memory storage, state machines, and frequency dividers. A Y_2O_3-based memristive crossbar array (MCA) (30×25) was fabricated on a 3-inch silicon wafer, and a detailed investigation of its resistive switching characteristics was conducted. The experimental results validate the Y_2O_3-based model for both individual memristors and MCAs, confirming stable switching behavior with minimal device-to-device (D2D) and cycle-to-cycle (C2C) variability.

The designed flip-flops were implemented and simulated using Cadence Virtuoso software at 180nm and 90nm technology nodes. The proposed designs take advantage of the non-volatile and compact nature of memristors to achieve superior performance. The circuits were evaluated in terms of power consumption, delay, and component count, demonstrating significant advantages over traditional CMOS-based flip-flops. Additionally, a hybrid memristor-based NOT gate was developed to showcase reconfigurable logic operations.

The results show that the proposed memristor-based SR, MS-D, JK, and T flip-flops achieve power savings of 50.84%, 54.17%, 46.85%, and 92.68%, respectively, along with delay reductions of 59.3%, 31.19%, 35.19%, and 27.55%. Furthermore, memristor-based SR, MS-D, JK, and T flip-flop circuits exhibit notable reductions in the number of components, achieving 90%, 84.78%, 80%, and 85%, respectively, compared to CMOS logic circuits. Additionally, the hardware implementation of a hybrid memristor NOT gate demonstrated an output voltage of 800mV, confirming its feasibility for Boolean logic operations. These findings highlight the potential of memristors in developing low-power, high-speed, and compact digital circuits. Furthermore, this study also demonstrates the application of the proposed flip-flops in a frequency divider circuit.

Hexagonal Shaped 4-Port MIMO Filtering Antenna with High Gain & Low Mutual Coupling

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A 4-port multiple-input multiple-output (MIMO) antenna exhibiting low mutual coupling and High Gain is developed for UWB applications. The hexagonal-shaped four antenna elements are connected with a 50 Ω microstrip feed line that is arranged rotationally to achieve the orthogonal polarization for improving the MIMO system performance.

The antenna is designed and simulated using Ansys HFSS software, and fabricated on FR_4 substrate with dimensions 60 x 60 mm^2. The antenna parameters are measured using VNA testing Agilent N5247A: A.09.90.02. For electromagnetic measurement and characterization the antenna was tested in anechoic chamber range 1GHz to 20 GHz. The results in the form of S-parameters, omnidirectional radiation patterns (E & H field), peak gain (7 dBi), Total Active Reflection Coefficient (TARC), Envelope Correlation Coefficient (ECC), Diversity Gain (DG), Channel Capacity Loss (CCL) and Polarization Ration (LHCP & RHCP) are illustrated in this paper to validate the suggested antenna performance.

The antenna has a wideband impedance bandwidth of 6.7 GHz with S_{11} < -20 dB from 17.50GHz to 24.20 GHz and inter-element isolation higher than -20 dB. As well, time-domain analysis was investigated to demonstrate the operation of the suggested antenna in wideband applications. The simulated and experimental outcomes show excellent inter-element isolation and Filtration characteristics making the antenna suitable for its use in UWB MIMO Filtenna applications.

Multilevel Nanophotonic Resistive Switching in Ag-ITO-SiO_2 on Silicon with Enhanced Optical Storage Density

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Multilevel resistive devices have gained significant research attention over the past decade due to their promising applications in high-density non-volatile memory and unconventional computing. We propose an engineered multilevel nanophotonic resistive switching device with a CMOS-compatible Ag-ITO-SiO2 structure on silicon, offering enhanced storage density and in-memory computing with optical readout functionality.

The device features a four-layered structure comprising a SiO_2/ITO region strategically positioned between an efficient Ag (top) electrode and a p-Si (bottom) electrode. The hybrid plasmonic modes are primarily confined within the $10\ nm$ SiO2 region at a subwavelength scale, operating at the telecommunication wavelength of $1550\ nm$. An external voltage is applied to induce the formation and annihilation of Ag filaments along the ITO and SiO_2 regions. This method demonstrates a unique interplay of materials and mechanisms, incorporating hybrid plasmonic confinement and optimizing improved opto-conductive filament interaction, enabling optical absorption modulation detectable via guided hybrid plasmonic modes.

The proposed engineered nanophotonic device achieves stable multiple optical states by controlling compliance current. It can store two bits of data without compromising accuracy, enabling parallel computing and efficient area savings with enhanced storage density for in-memory computing applications on a photonic platform. Additionally, experimental results demonstrate a significant extinction ratio of 32 dB for the 10 μm × 500 nm device operating at low voltage. The engineered nanophotonic structure exhibits high retention ($\sim 5 \times 10^3\ seconds$), high endurance, low operating power, and high-speed operation, making it suitable for various applications, including efficient and high-performance functionalities in optical interconnects, high-density advanced memory devices, optical modulation, neuromorphic computation, biochemical sensing, photogating, and reconfigurable nanophotonic circuitry.

TMD-Based IoT-Enabled E-Nose for Real-Time Detection of Toxic Gases at Room Temperature with Enhanced Safety Alerts

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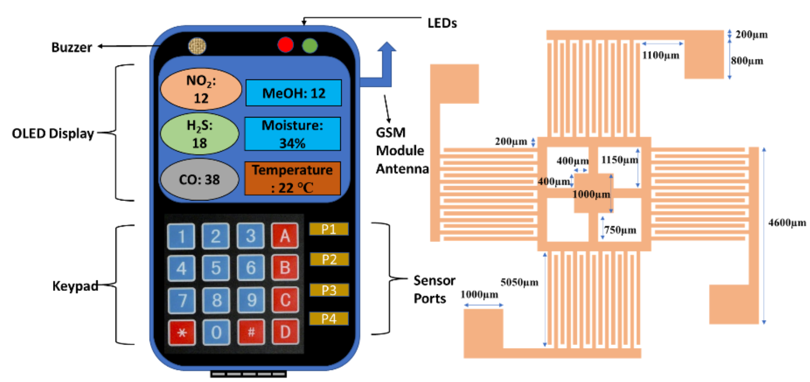
This work aims to develop a real-time IoT-enabled e-nose for detecting four toxic gases at trace levels, enhancing environmental monitoring and safety. The system ensures rapid hazard detection with emergency alerts via notifications, SMS, and calls, making it ideal for industrial and residential safety applications.

The e-nose incorporates four selectively synthesized MoS_2-based sensors: pristine MoS_2 monolayers via APCVD for NO_2, Pd-loaded MoS_2 nanoflowers via hydrothermal synthesis for methanol, Pd-doped MoS_2 thin films via CVD for H_2S, and Ni-doped MoS_2 monolayers via CVD for CO detection. These materials are integrated into a custom-designed IDE device, interfaced with an ESP32 microcontroller, GSM modules, LEDs, and buzzers for real-time alerts. The system was developed using Proteus simulations, PCB fabrication, and component assembly. A multilingual Android mobile application, synced with Firebase cloud storage, enables real-time visualization and historical data storage for up to four months, enhancing usability and accessibility.

The developed sensors exhibited high sensitivity, selectivity, and rapid response to their respective target gases. Calibration for NO_2 detection has been secured through NABL accreditation, while the remaining sensors are undergoing certification to ensure accuracy and compliance with industry standards. The emergency alert system ensures immediate warnings and escalation in case of prolonged gas exposure. The IoT-enabled mobile application allows real-time monitoring, historical data storage, and multilingual support, enhancing user accessibility. The platform's capability to integrate additional sensors makes it a scalable and adaptable solution for various applications, including industrial safety, environmental monitoring, and residential gas detection. By providing accurate and real-time toxic gas detection, this system significantly contributes to public health, pollution control, and workplace safety.



Analysing the Effect of Different Mordanting Techniques on Cotton Fabric Dyed with Onion Peel Extract

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Natural dyes are becoming prominent due to their eco-friendly, biodegradable, and non-toxic properties. The study aims to analyze the various shades obtained through three mordanting phases – pre, simultaneous, and post. For this study cotton fabric was utilized, and onion peel extract was used for dye extraction in combination with the alum as mordant.The influence of alum on dye absorption and fixation is significant for optimizing natural dyeing techniques and promoting sustainable textile production.

Dried onion peels were soaked in the aqueous solution and heated to extract the dye from the onion peel extract, using the solvent extraction method. This method ensures that compounds from the dyes are extracted efficiently. To study the impact of alum on color development, its treatment was given in three different mordanting techniques. In pre-mordanting fabric was treated with alum before dyeing while in simultaneous mordanting alum was directly used in the dye bath. Post-mordanting involved treating the fabric with alum after dyeing the fabric. The dyed samples were analyzed for evaluation shade variations and dye fixation.

These results showed that alum mordanting notably exert influence on the final shade, giving variable hues. Pre-mordanting gives lighter shades, on the other hand post Mordanting yields richer and intense colors, due to enhanced dye absorption. Simultaneously Mordanting gives moderate shades with uniform distribution. These findings focus attention on the efficacy of alum in enhancing dye uptake and fastness of color while exhibiting the potential of onion peels as environmentally conscious dye source. This study contributes to the booming field of environmentally conscious textile dyeing by giving insights into optimizing natural dyeing techniques for experiential and commercialised implementation.

Development of Amplification Free Antibiotic Resistance Gene Detection Platform for Surveillance of Aminoglycoside Resistance in Wastewater

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Emergence of multiple drug resistant (MDR) bacteria pose a global threat to public health. Sewage water lines facilitate a safe sanctuary for these pathogens to flourish by providing ambient conditions for the exchange of resistance genes. Aminoglycoside resistance genes are amongst the most transmittable factors, as they are found on exchangeable extrachromosomal plasmids. A robust detection system for surveillance can assist in analysing resistance patterns.

This study aimed at developing an amplification free CRISPR based detection for surveillance of resistant bacteria. PCR based screening for aminoglycoside resistance genes was conducted using wastewater samples collected from Swarna Rekha Drain system of Gwalior District, M.P. Further, pathogenic species harbouring these genes were identified using conventional culturing techniques followed by 16s rDNA sequencing. Identified resistant bacterial species were chosen as the target for development of a CRISPR detection system.

We were able to identify and confirm the presence of 5 aminoglycoside resistance genes in the collected waste water samples. Subsequently, the presence of *npmA* resistance gene in a *Klebsiella pneumoniae* strain was confirmed. The multiple guide-RNA based CRISPR detection system was able to identify the designated targets with a detection limit of 50 ng/µl using DNA from pure culture dilutions as target. The efficiency of this platform was tested for surveillance of real-world wastewater samples, wherein the detection limit was found to be ~10^6 colony forming units per millilitre of sample.

Ecological and Habitat Fragmentation Studies of *Ompok bimaculatus* of Three Rivers of Madhya Pradesh inferred through responsible Mitochondrial Genes

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Ompok bimaculatus (Bloch, 1794) is a butter catfish belong to family siluridae, which is locally called as 'Pabda' in central region of India. It has a good market demand as this species is considered as esteemed and tasty food fish in the Indian sub-continent subject to the targeted fisheries. It is occasionally caught and exported as an ornamental fish, hence prone to over-exploitation and major anthropogenic threats, therefore, the population of *Ompok bimaculatus* is gradually declining hence, it considered per near threatened species as per IUCN Red List Data (2020) resulting that the genetic stock of this species is also declined and fragmented.

The estimation of genetic stock of *O. bimaculatus* was studied in the three major rivers of Madhya Pradesh, which was aligned for estimation of habitat fragmentation by estimation of gene flow, nucleotide diversity (π), haplotype diversity (Hd) was carried out by PCR technique. 3-5 individuals of *O. bimaculatus* were caught from each sampling sites of each river and brought to the laboratory for further studies. The genomic DNA extraction, quantification, PCR amplification (by *mtcox1*, *cytob*) and consequently DNA sequencing was performed and delineated habitat fragmentation.

Initially, collected specimens were identified using morphometric methods and molecular identification with the help of mitochondrial *cytochrome oxidase I* gene (*mtcox1*). All the sequences used for identification were barcoded for the validation purposes which are globally available on BOLDSYSTEMS, USA. Sequenced mt*cox1* gene sequences are also submitted to GenBank NCBI, USA and accession numbers PP813420, PQ394644, PQ394651, PQ566017, PQ566018, PQ566019, PQ738172, PQ738173, PQ738174, and PQ738175 for identification purposes. Habitat fragmentation and ecological turbulences were studied by finding variations and alterations of *mtcox1* and *cytob* gene sequence and Truss methodology by using morphometric parameters. All the database of *cytob*, mt*cox1* gene and Truss statistics showed that *O. bimaculatus* is on high alert for conservation point of view based on the gene flow, haplotype diversity and F-statistics are very low if, compared species with the standards and other studies carried out by various scientists. Therefore, the conservation of genetic stock of this species is required by making action as well as working plans by different concerned departments.

Degradation and In-vitro Toxicity Analysis of Byproducts from Teflon Coated Cookware at Cooking Temperature Conditions

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Non-stick cookware, coated with Polytetrafluoroethylene (PTFE) is recognized as a convenient choice for hassle-free cooking and cleaning. Cooking typically occurs at temperatures below the melting point of PTFE and is assumed to be putatively safe. This study evaluates the thermal stability of PTFE using single-shot thermogravimetric analysis (TGA) and stepwise TGA which mimics the real-life scenarios experienced during cooking, simulated with cycles of stepwise heating/cooling in a TGA. Py-GC-MS revealed that at cooking temperatures (220℃ and 260℃), PTFE breaks down into Perfluoro carboxylic acids (PFCAs). During regular use, the PTFE degradation products leach into food during cooking and enter the digestive system. This highlights the need for comprehensive studies on the toxicity of these PFCA's, not only individually but also in their binary and ternary combinations, including their combined and additive toxic effects. This study investigates the individual, combined, and additive toxicity of PFCAs in human gastric (AGS) cell lines. In-vitro cytotoxicity of these compounds was determined, followed by in-vitro assessments of Reactive Oxygen Species (ROS) and cell death using H_2DCFD-A and EB-AO assays, respectively. Gene expression analysis of tumor suppressors (p53, caspase-9) and proto-oncogenes (BCl2, CCND1) revealed increased ROS activity and higher cell toxicity in combined treatments. The upregulation of proto-oncogenes and downregulation of tumor suppressors confirmed enhanced toxicity in multiple compound exposures in AGS cell-line. Thus, this study helps to understand the toxicity of these compounds on human cells.

Phytoremediation Potential of *Brassica juncea* for the Removal of Lead from Contaminated soil

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Heavy metal pollution poses a threat to human life. This study examined the known lead (Pb) accumulator *Brassica juncea* in a clay pot experiment and explored the Pb accumulation and tolerance in the Indian mustard cultivars Varuna and SVJ-64. Growth and Pb accumulation were determined at 45 days after emergence. Additionally, we assessed their potential impact on physiochemical parameters in *Brassica juncea* as well as phytoextraction of Pb contaminated soil. Both varieties of *B. juncea* demonstrated strong Pb accumulation and tolerance, with translocation factors near to 1 at Pb levels of 112mg/kg, according to the clay pot culture experiment with 0-140mg/kg Pb concentrations. Comparative analysis revealed that the Varuna variety accumulated more Lead than the SVJ-64 variety at 56 to 140 mg/kg Pb in the soil and even at higher concentrations of Pb in the soil. The reduction in physiochemical variables also increases as Pb content rises, especially in the SVJ-64 type. The aforementioned findings suggest that Varuna variety is a superior option for Pb phytoextraction in soil that has been contaminated with Pb. The outcomes serve as a guide for Pb pollution mitigation. Our findings indicate that *B. juncea* has the potential to accumulate Pb in soil under tropical conditions.

Characterizing Light Absorption by Brown Carbon Aerosols in Eastern Madhya Pradesh

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B*rown* carbon (BrC) aerosols, a subset of organic carbon aerosols, absorb light in the ultraviolet and visible wavelengths and are produced primarily from biomass burning, industrial emissions, and other combustion sources. Their optical properties play a key role in atmospheric heating and aerosol–climate interactions, yet they remain less studied compared to black carbon. Understanding BrC is critical for improving climate models and addressing air quality and radiative forcing issues. This study focuses on the Shahdol district of Madhya Pradesh, a representative coal mining region where coal burning and biomass burning are prevalent during the winter season.

Particulate matter ($PM_{2.5}$) samples were collected and analyzed for optical properties using a UV-visible spectrophotometer. The water-soluble fraction of aerosols was extracted through sonication, filtered, and the mass absorption coefficient (b_{abs}) and absorption angstrom exponent ($AAE_{380/500}$) between 380 and 500 nanometre (nm) were determined.

Results showed that $PM_{2.5}$ concentrations slightly exceeded the prescribed limits set by the Central Pollution Control Board (CPCB). MAC values ranged from 6 to 27 Mm^{-1} (unit in inverse of megameter), and AAE values were mostly greater than 1, indicating multiple sources. Specifically, an AAE value near 2 suggests biomass burning as the dominant source, values around 1.5 reflect a mixture of biomass and fossil fuel sources, while values less than 1 suggest black carbon from fossil fuel combustion. These findings highlight the complex aerosol sources in the region and their potential climate impact. This study enhances our understanding of BrC aerosols, offering insights into their role in regional air quality and climate forcing, which is crucial for refining climate models and developing effective emission control strategies.

Changing Precipitation Pattern across Indian Key Biodiversity Areas and Aquatic Ecosystem Risk for Coastal Ramsar Wetlands

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India is home to over 628 key biodiversity regions, spanning diverse climates and ecosystems, with the highest concentration of these regions located in its four biodiversity hotspots. Climate change and human activities are increasing the threats to the region's flora and fauna. The Western Ghats, for instance, are one of the most densely populated regions globally, while the Himalayan region is experiencing warming at a rate higher than the global average. India also boasts the largest number of Ramsar sites in South Asia, covering 1.33 million hectares, with 73.32% of this area found in 16 coastal wetlands. However, these wetlands face significant decline due to changing precipitation patterns, rising sea levels, and anthropogenic pressures such as land-use changes and pollution.

This study evaluates the precipitation variability in biodiversity regions, focusing on the impacts of extreme precipitation events and droughts. Using general extreme value analysis, the research examines how climate change, driven by global climate oscillations and their nonstationary behaviour influences these regions. For coastal Ramsar wetlands, the study assesses hazards by analysing extreme precipitation return levels, water quality indices (NDCI, NDTI), and land cover patterns. Findings indicate that extreme precipitation events, influenced by oscillations like ENSO, IOD, and AMO, are projected to increase along the western coast. Wetland vulnerability is evaluated using a health scorecard, considering the exposure to ecosystem services to gauge the risk to aquatic ecosystems.

The study found that precipitation variability has a significant impact on regions like the Western Ghats, with certain wetland sites facing higher risks. Among these, Pallikaranai Marsh Reserve Forest, Thane Creek, and Aghnashini Lake were identified as the most vulnerable. Pallikaranai Marsh, in particular, was found to be at extreme risk due to its low wetland health score, combined with high exposure to ecosystem services and hazard values. These findings highlight the urgent need for targeted interventions. The study provides a foundation for developing resilience strategies for ecosystem restoration, considering site-specific risks. It underscores the importance of addressing climate-induced threats while promoting biodiversity conservation and climate adaptation strategies.

Analysis and Evaluation of Municipal Solid Waste: Assessing Dumpsite Waste Generation and Environmental Implications in Chitrakoot (M.P.)

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Rapid population growth, urbanization, and industrialization have increased waste generation, but inadequate municipal collection and lack of advanced treatment technology led to pollution. The objective of this study was measuring generation and compare municipal solid waste composition at Chitrakoot (MP). Waste sorted out into several components such as plastic, paper, metal, glass and other type of waste. The paper aims to characterize the waste generated in municipality of Chitrakoot (M.P), in the state of Uttar Pradesh India. Municipal solid waste sampling and laboratory analysis were carried out on random sampling method by using American standard test method (ASTM) standard for Moisture content was analysed by drying at 75-100°C for 24 hours. C, N, and O using a CHN analyser (EA1108) and K and P were analysed via flame photometry, Analysis heavy metal in solid waste sample carried out by atomic spectrophotometry and pH analysis Carnes (1970) using a pH meter. During the summer (April), dry conditions result in limited decomposition, high organic carbon levels (3.75%), and stable heavy metals (Pb, Zn) due to low moisture (2.73%). In the monsoon season (July), increased rainfall accelerates organic waste decomposition, reducing organic carbon (1.76%) while enhancing microbial activity and nutrient cycling, with slight increases in nitrogen (N) and phosphorus (P). However, soluble elements like potassium (K) and sodium (Na) decline due to leaching, and heavy metals exhibit signs of runoff. Post-monsoon (October), decomposition stabilizes, with peak moisture content (14.1%) and organic carbon levels recovering (3.5%). Phosphorus levels (24.10 mg/kg) rise, while potassium (K) drops to its lowest (0.11 mg/kg), and heavy metals continue to decline, suggesting persistent leaching. These findings underscore the need for efficient waste management practices to mitigate environmental risks and promote sustainability.

Parenting in the City: Investigating Sex-based Differences in Parental Care Behaviour in House Sparrows across Urban and Rural Habitat

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Urbanization reshapes ecological landscapes, influencing species distribution, resource availability, and predation risks. As cities expand, wildlife are forced to adapt to overcome novel challenges. Parental care, which plays a critical role in survival of altricial species (species with dependant offsprings), is one such adaptation that remains poorly understood. House Sparrows (*Passer domesticus*), a globally widespread human-commensal species, serve as a model to understand how anthropogenic changes impact reproductive behaviors and fitness. In this study we examine sex-based differences in biparental care across urban and rural habitats and their implications for reproductive success.

We studied eight rural and nine urban sparrow populations by manually observing 144 previously installed nest boxes, ensuring minimal disturbance. We quantified the male and female contribution towards the following parental care behaviors: nest construction, guarding, incubation, and food provisioning, during the peak activity time. Reproductive fitness was measured via clutch size, hatchling and fledgling success which were assessed using an endoscopic camera. We used linear mixed-effects models to assess the effects of habitat and sex on parental investment using the lme4 package in R.

Our results show that the total parental investment was significantly higher in urban populations when compared to their rural counterparts. This difference was driven primarily by the females, while male investment remained consistent across habitats, suggesting intrinsic constraints on male effort. Despite higher parental care, the hatchling and fledgling success were lower in urban areas, likely due to limited or poor food quality, intensified predation pressure, and anthropogenic disturbances. These findings underscore the adaptive plasticity of parental care in response to urban stressors while highlighting the potential fitness costs associated with urban living. Understanding these behavioral adjustments is essential for predicting species resilience in rapidly urbanizing landscapes and informing conservation strategies.

Unraveling the Neurotoxic Effects of Cigarette Smoke Extract on Zebrafish Brain: A Comprehensive Study of Neurodegeneration and Cognitive Decline

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Neurodegeneration involves the progressive loss of neurons and cognitive function. Cigarette smoke, containing a complex of around 7,000 chemicals—69 of which, including arsenic, chromium, nitrosamines, nicotine, and formaldehyde, are particularly harmful—induces oxidative stress, inflammation, and neuronal loss. While the link between cigarette smoke and diseases like cancer, cardiovascular issues, and lung damage is well-established, its neurotoxic effects on the brain, leading to cognitive decline and neurodegeneration, remains less explored and unclear.

The current study investigates behavioral, biochemical, and histopathological changes in adult zebrafish exposed to cigarette smoke extract and evaluates the neuroprotective potential of hesperetin, a natural flavonoid with antioxidant and anti-inflammatory properties.

Adult zebrafish were acclimatized for two weeks under optimum conditions and divided into groups exposed to CSE and hesperetin. Behavioral assessments, including the novel tank test, open field test, swimming behavior test, and dark-light test, were conducted on the final day of the experiment. Biochemical analysis was performed to evaluate oxidative stress markers, while histological examinations of brain sections assessed structural integrity and alterations across various brain regions.

CSE exposure exhibited impaired behavioral functions, including reduced memory and cognition, anxiety-like behavior, and altered locomotor activity. Biochemical assays revealed increased oxidative stress, reduced antioxidant activity, elevated proinflammatory cytokines, and inhibited AChE activity, indicating cholinergic dysfunction. Histopathological analysis indicates pyknosis and neuronal loss. Co-treatment with hesperetin alleviated these effects by improving cognitive function, reducing inflammation and oxidative stress, restoring AChE activity, and preserving neuronal integrity**.**

The above findings highlight the neurotoxic effect of CSE and the neuroprotective efficacy of hesperetin against cognitive impairment and neurodegeneration. This study underscores the therapeutic potential of hesperetin in mitigating environmental toxin-induced Alzheimer 's-like neurodegenerative disorders and warrants further exploration for its therapeutic interventions.

Water Quality in Upper Lake, Bhopal, India: A Physical-Chemical Assessment with Particular Attention to Phosphate and Nitrate Concentrations and Their Effects on the Lake Ecosystem

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In 2023–2024, the Physico-chemical condition of Upper Lake (Bhopal, India) was examined, with particular attention to phosphate and nitrate. Two key nutrients in the lake are phosphate and nitrate, which are loaded by point and non-point pollution sources such swimming, washing, farming in the periphery, connecting household raw sewage, trapa cultivation, and the massive growth of aquatic macrophytes. These nutrients help the aquatic plants (mostly Hydrilla, Ceratophyllum, and Eichhornia crassipes) grow quickly. Consequently, these plants cause the wetland area to gradually shrink along with other issues like poor light penetration, decreased oxygen concentration, clogged water channels, decreased lake entertainment value, and occasionally a drop in oxygen levels that can result in fish mortality.

Therapeutic Potential of Natrum Sulphuricum and Natrum Phosphoricum in Liver Cirrhosis and Hepatic Encephalopathy: Targeting Protein Misfolding and UPR Pathway Genes

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Alcohol use disorders are a major contributor to global mortality. Acetaminophen, a widely used non-steroidal anti-inflammatory drug (NSAID), is often misused to relieve hangover symptoms. The combined use of alcohol and acetaminophen intensifies liver damage, with protein misfolding and the unfolded protein response (UPR) playing key roles in the progression of liver cirrhosis and hepatic encephalopathy. Natrum sulphuricum (NS) and Natrum phosphoricum (NP) are traditionally used to manage liver disorders. This study focused on identifying nanoparticles in NS and NP and exploring their potential therapeutic mechanisms in UPR pathway.

Presence of nanoparticles were observed by FTIR and UV-Vis spectroscopy. Behavior tests were also performed. To investigate the hepatoprotective effects of NS and NP, liver cirrhosis was induced in rats through chronic exposure to 4.5% alcohol and acetaminophen (300 mg/kg body weight) for seven days. Animals were then divided into five groups: normal control, alcohol control, liver cirrhosis (LC) control, LC+NS (50 mg/kg), and LC+NP (50 mg/kg). Treatments were administered via drinking water for four weeks. Expression levels of key UPR markers were analyzed using quantitative RT-PCR, western blotting and IHC.

Sodium sulfate and sodium phosphate nanoparticles found in NS and NP. The behavioral analysis shows that there must be some brain damage found in liver cirrhosis induced hepatic encephalopathy, NS and NP positively alerted the brain function. NS and NP treatment also restored the level of UPR towards normal which were affected due to LC.

This is the first report of its kind reporting the efficacy of NS and NP as global agents halting the expression of altered protein misfolding and genes of UPR pathway in chronic alcoholism and acetaminophen induced liver cirrhosis. The findings from the present experiment are expected to provide an in-depth insight into the mechanism of action of biochemic tissue salts.

Production of β-mannanase from A. tamarii NKRC1229 using Copra Meal and its Immobilization for Mannooligosaccharide (MOS) Synthesis

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Lignocellulosic biomass, rich in cellulose, hemicellulose, and lignin, is underutilized despite its vast potential. β-Mannanases, produced by fungi like *A.tamarii*, degrade mannans, converting agro-waste like copra meal into prebiotics and enzymes. This study optimized β-mannanase production *from Aspergillus tamarii* NKRC1229, immobilized it on green-synthesized FeNPs, and analyzed MOS generation and enzyme functionality via *in silico* methods.

A.tamarii produced β-mannanase using copra meal in SSF, optimized via OVAT. The enzyme, purified and immobilized on FeNPs, showed enhanced stability and reusability, hydrolyzing mannans into mannooligosaccharides (MOS) confirmed by TLC, HPLC, and FTIR. Molecular modeling and docking validated its structure and substrate interactions for industrial applications.

Optimization using the one-variable-at-a-time approach led to an 11.2-fold increase in β-mannanase yield (790.1 U/gds). The partially purified enzyme (75 kDa), obtained through Sephadex G-50 resin, exhibited a specific activity of 225.91 U/mg and was immobilized on FeNPs, resulting in significant enhancements in thermal and pH stability, with an optimum pH of 5.0 and temperature of 70 °C. The immobilized enzyme demonstrated excellent stability in the presence of various inhibitors and activators, retaining over 50% of its activity after seven cycles. HPLC analysis revealed that β-mannanase hydrolyzed locust bean galactomannan, konjac glucomannan, and guar gum, producing MOS at yields of 46.32 mg/mL, 34.80 mg/mL, and 1.37 mg/mL, respectively. The enzyme's structural and functional characteristics, along with substrate-binding preferences, were elucidated through in silico studies. Structural quality was validated using the Ramachandran plot and Z-score, while molecular docking demonstrated strong interactions between β-mannanase and galactomannan, with a binding affinity of -7.8 Kcal/mol, aligning with experimental findings.

Overexpressed Nup88 Stabilized through Interaction with Nup62 Promotes NF-κB Dependent Pathways in Head and Neck Cancer

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Bidirectional nucleocytoplasmic transport, regulating vital cellular processes, is mediated by the Nuclear Pore Complex (NPC) comprising the nucleoporin (Nup) proteins. Nup88, a constituent nucleoporin, is overexpressed in many cancers, and a positive correlation exists between progressive stages of cancer and Nup88 levels. However, mechanistic details of Nup88 roles in tumorigenesis are sparse.

We utilized online available cancer datasets, along with oral cancer patient tissue samples and cell lines to analyse Nup88 and Nup62 in tumors. We further employed immunoprecipitation, pulldown assays, tumorigenic assays, FACS and immunofluorescence techniques to gain mechanistic details regarding aberrant expression of these nucleoporins in oral cancer development.

Nup88 and Nup62 levels are significantly elevated in head and neck cancer patient samples and cell lines. The elevated levels of Nup88 or Nup62 impart proliferation and migration advantages to cells. Interestingly, Nup88-Nup62 engage in a strong interaction independent of cell-cycle stages. This interaction with Nup62 stabilizes Nup88 by inhibiting the proteasome-mediated degradation of overexpressed Nup88. Overexpressed Nup88 stabilized by interaction with Nup62 can interact with NF-κB (p65) and sequesters p65 partly into nucleus of unstimulated cells. NF-κB targets like Akt, c-myc, IL-6 and BIRC3 promoting proliferation and growth are induced under Nup88 overexpression conditions. In conclusion, our data indicates that simultaneous overexpression of Nup62 and Nup88 in head and neck cancer stabilizes Nup88, which interacts and activates p65 pathway, which perhaps is the underlying mechanism in Nup88 overexpressing tumors. Notably, recent studies have highlighted the significance of inhibiting nucleoporins in cancer, as it only reversibly affects normal cells. Our study provides significant mechanistic insights about the functioning of nucleoporins in cell and how their differential expression (commonly observed in several cancers) mediates tumor development. This has been a major challenge for studies concerning NPC investigations in recent times that require to be elucidated to combat malignant transformations.

Metaviromics Reveals the Diversity in *Aedes* Mosquitoes from Central India, Gwalior

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Vector-borne infections are a serious worldwide health concern, accounting for 17% of infectious diseases that afflict people. Numerous arboviruses, which cause diseases like Dengue, Chikungunya, Zika, West Nile, and Japanese encephalitis, are primarily spread by mosquitoes.The importance of omic technologies in surveillance and epidemic prepardness was highlighted in COVID-19 outbreak. Metagenomics or metaviromics proves to be a useful method for studying mosquito virus diversity. Recent advancements in metagenomic research have helped with environmental surveillance, obtaining data on the existence of various viruses and advancing our knowledge of disease pandemics.Thus, in order to investigate mosquito borne viral infections, monitoring of mosquito virome becomes crucial.

In this study, Aedes mosquitoes were collected from different hotspot areas of Dengue and Chikungunya infections in Gwalior. Pools of mosquitoes were processed and sequenced by both short read ION Torrent platform and long read Oxford Nanopore Platform. Bioinformatic analysis was done using two different pipelines : Genome Detective Platform and CHAN ZUCKERBERG ID (CZID). Nanopore raw data was also analysed using GUI based Commander software provided by Genotypic Technology Pvt. Ltd, Bengaluru, India.

Bioinformatics analysis from different pipelines revealed a large no. of insect specific viruses like Phasi Charoen-like virus (PCLV), Wenzhou sobemo-like virus 4 (WSLV), Hubei mosquito virus (HMV), Humaita-tubicanga virus (HTV) etc. Viral families like *Myoviridae, Mimiviridae, Iridoviridae, Bunyaviridae, Flaviviridae,* and *Mesonivirdae* were found varying in abundance. The identification of plant and animal viruses provided insight of mosquito interaction with plants and animals for nectar and blood meal. This methodology can further be used for routine surveillance, deepening knowledge regarding the existing viruses and hence enabling for better vector control and prevention strategies**.**

SUMOylation of Coronin 1C is a Requisite for Actin Rich Cellular Projections and Neuronal Differentiation

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The Coronin family of proteins binds actin and modulates actin-dynamics-dependent cellular processes. Coronin1C (COR1C) actively associates with actin at the leading edge of the cell. Post-translational modifications, such as SUMOylation, regulate functions and cellular interactions of proteins. We identified COR1C to be a SUMO target in a proteomic screen. We aimed to validate the SUMOylation of COR1C by *in bacto* and *in cellulo* analysis and characterize its cellular significance in maintaining the cytoskeletal integrity.

Site directed mutagenesis was performed to identify the lysine residues which undergo SUMOylation. Expression of SUMOylation resistant COR1C mutants in mammalian cells and confocal imaging was performed to study the effects of COR1C on actin rich cytoskeletal structures like filopodia and dendrites/neurites.

Through our *in vitro* analysis, we conclude that COR1C is SUMOylated in its C-terminus preferentially by SUMO1. Expression of the C-terminal of Coronin1C (COR1C-C) lacking five potential SUMOylatable lysine residues (5KR mutant) resulted in a decrease in the filopodia formation. A corroborating observation of filopodia formation was made in cells treated with TAK981, a SUMOylation inhibitor. We also observed that SUMOylation of COR1C is important for efficient neuritogenesis and neuronal differentiation in Neruro2a cells. Further, the 5KR mutant COR1C-C forms cytoplasmic aggregates under neuronal differentiation conditions, a hallmark of neurodegenerative diseases (NDDs). Thus, SUMOylation of Coronin1C can impair cellular migration, modulate neuronal granule formation attributed to prevention of NDDs as neurons start aging.

Studies on Extracellular Phospholipase Enzyme Produced by Clinical Isolates of Fungi Isolated From Fresh Water Fishes with Reference to Jabalpur Region

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The production of fresh water fishes *catla catla* trade has increased significantly over the past decade. Concerning the high demand for fresh water fishes, these freshwater fish are susceptible to fungi infection that can cause mortality to individual and fish eggs. The purpose of this study is to determine their extracellular enzymes for virulent screening. Six fishes with apparent signs of infection such as ulcerative, haemorrhages and dermal lesions were collected from Gaur river, Jabalpur (MP).

Study was conducted for the screening of phospholipase production by all the strain isolated from fresh water fishes. The amount of enzyme production by the strains was determined by calculating their Pz values on the 5th and 8th day of incubation. Then the zones around the colonies were observed. The radius of the clearing zone was measured and considered criteria for extracellular phospholipase activity of fungal isolates. The visible precipitation zones of the test solutions were measured after 3^{rd} and 5^{th} day of incubation. The zone estimation was done by using the zone reader (Himedia).

The dense white zone of precipitation around the colonies of phospholipase positive isolates was distinctive and well defined. The test strain of fungi that was screened for this study turned out to be a productive source of enzymes that break down proteins and polysaccharides. The production of the extracellular phospholipase enzyme by *Aspergillus*-like species demonstrated the isolate's virulence and potential to spread infection.

Metabolomic Approach for Evaluating the Therapeutic Potential of Eugenol-Loaded Chitosan Nanoparticles in Allergic Airway Inflammation via NF-κB, MAPK, and HDAC Pathways: *In Vivo* and *In Silico* Analysis

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Eugenol, a major phytoconstituent derived from *Syzygium aromaticum L.*, demonstrates potent anti-inflammatory properties supported with numerous pharmacological studies and effectively mitigates asthma-associated inflammation. The study is focused on enhancing the thermal stability of eugenol by encapsulating it in chitosan nanoparticles via ionic gelation, improving its anti-inflammatory and immunomodulatory potential. Formulation development and optimization of chitosan nanoparticles by Design of Experiment (DoE) was performed. We examined the potential of EUGCNP to mitigate asthma pathogenesis by suppressing NF-κBp65 and modulating HDAC1. EUGCNP (10 mg/kg) was administered to Balb/c mice following OVA exposure to establish an allergic asthma model. The impact of EUGCNP on NF-κBp65, MAPKp38 and HDAC1 signaling pathways were assessed by examining various inflammatory parameters through immunofluorescent localization, also H&E and Masson's trichrome staining were performed. Metabolomic analysis of BALF and lung tissues identified unique metabolic signatures, while ELISA quantified pro-inflammatory cytokines such as IL-13, IL-4, IL-5 and TNF-α. Serum levels of NO, ALT, AST, and creatinine, along with MDA, GSH, SOD, and CAT were quantified in lung tissue. Molecular Dynamic Simulation and Molecular docking analysis was also performed. Eugenol-loaded chitosan nanoparticles (EUGCNP) particles, sized 50–200 nm, demonstrated improved dispersibility from electrostatic hydrogen bonding, as observed through SEM and TEM. Metabolite analysis between Control and OVA groups shows disrupted energy, amino acid, and lipid metabolism in asthma, indicating cellular stress and altered energy metabolism in OVA group. The restoration of these metabolites confirms that EUGCNP may alleviate lung injury and restore metabolic balance in asthma. Augmented expressions of HDAC1, MAPKp38 and NF-κBp65 were observed in asthmatic group which were suppressed in the treatment group. The findings suggests that EUGCNP attenuate asthma severity and airway inflammation via down regulation of HDAC1, and NF-κBp65 in an ovalbumin-induced asthmatic mouse model.

Development of DNA Barcodes Database of *Filopaludina Bengalensis* for Accurate and Comprehensive Identification and Authentication Purposes

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The gastropods consist of snails and slugs from freshwater, saltwater and lands are one of the best studied classes of invertebrates found abundantly in tropical intertidal areas. Still, most of the species have been delimited based on morphology only. In addition to serving as a means of self defense or protection, gastropod shells can be used for species identification but only morphological identification is not sufficient for the identification, especially in case of closely related species.

To overcome the problem of delimitation, DNA barcoding can be used for the confirmation of species accurately. Mitochondrial DNA Cytochrome Oxidase subunit 1 (*mtcox1*) gene was used for the molecular identification which involved genomic DNA extraction, primer-assisted DNA amplification and DNA sequences database creation with advanced bioinformatics software. Using comparison of available sequence database of GenBank, NCBI to study our data, and the identification was completed and sequences of *mtcox1* gene were 576 and 600 bp were obtained for the two samples. Based on the physical traits, the viviparidae gastropods were identified as *Filopaludina bengalensis*.

The genomic DNA was extracted using phenol: chloroform: isoamyl alcohol (25:24:1) method and good concentrations between 22.36 ng/ul to 2598.09 ng/ul with ±1.8 ratios of 260/280 were obtained. All the extracted genomic DNA samples were diluted as required for PCR amplification upto 40-60 ng/ul. The PCR amplification was performed using universal primers LCO1490 and HCO2198 and amplicons of ±700bp obtained successfully. Upon identification through the use of barcoding DNA, the submitted sequences matched 100% with *Filopaludina bengalensis* and 94.14% of sequences were matched with *Filopaludina doliaris* when compared our results with the available database of BOLD systems. It has been demonstrated that the use of DNA barcodes can be very helpful in defining species boundaries. Therefore, it is concluded that the two gastropods species under the study were successfully identified using *mtcox1* gene as a DNA barcode.

Impact of Withaferin-A on Diabetes Mellitus Induced Female Reproductive Dysfunction Mediated by GnRH-I in Brain and ERs in Ovaries of Swiss Albino Mice

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Type 2 diabetes mellitus (T2DM) is a chronic metabolic disease, characterized by persistent hyperglycemia resulting from diminished response to insulin secretion or resistance. The present study evaluated the ameliorative effects of Withaferin-A on T2DM-induced reproductive dysfunction in female mice. For the same, mice were received high fat diet followed by Streptozotocin injection intraperitoneally, (40 mg/kg/day) for 5 consecutive days to induce DM. Mice were then treated with WA (8 mg/kg/day) both in normal and diabetic conditions (DM+WA). Next, blood glucose levels, OGTT, oxidative stress and reproductive parameters were estimated. Immunofluorescent localization of GnRH-I in POA and PVN region of hypothalamus and ERα and ERβ in ovaries was performed for reproductive performance. Diabetes mellitus triggered reproductive dysfunction is mediated by low ir-GnRH-I in the brain, ERα and ERβ in the ovaries along with declined circulatory estradiol levels. Interestingly, treatment with WA significantly reduced the blood glucose levels and enhanced glucose clearance including oxidative stress in ovaries as indicated by low levels of H_2O_2 and MDA in DM+WA. We also observed reproductive immunity mediated by IL-10 and IL-1β and apoptosis exhibited by Caspase-3 and p53 in ovaries. However, there is hardly any conclusive study that reports the pharmacological effect of WA in T2DM-induced female reproductive dysfunction mediated by estrogen receptors (ERs) and their molecular docking studies. This study reports for the first time that WA can efficiently combat T2DM-induced reproductive dysfunction *via* enhancing endogenous estrogen and increased *ir*-GnRH-I in the brain and ERα and ERβ in the ovaries of the T2DM mice.

Docking analysis of Natural and Chemical Anti-Anemic Agents Targeting Specific Proteins

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Anemia, being one of the most significant genetic hematological disorders afflicting people of Indian descent, has been managed along with a plethora of other pathological conditions. Throughout this investigation, potential target proteins for drugs and bioactive are identified and evaluated. *In silico* analyses were conducted to assess the anti-sickling activity of bioactive agents. Chlorogenic acid and catechin, the bioactive found in wheatgrass and the betel plant, are being studied against anemia-related target receptors: hepcidin and transferrin. The assessment used the binding-free energy value and the interactions between the amino acids at the receptors and the ligand. Detailed evaluation of the ligands' binding positions revealed desirable interactions, such as hydrogen bonds, π-cation, van der Waals, and hydrophobic bonds. The results strengthen the body of research supporting the use of natural bioactives in treating anemia.

DNA Barcoding of Fish Species of Upper Lake, Bhopal, Madhya Pradesh: A Species Identification and Authentication and Consequently DNA Barcode Database Generation

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Upper Lake Bhopal is a significant wetland with several fish species and has been designated as a Ramsar site. However, anthropogenic activities such as habitat degradation and overfishing pose a threat and led to a drastic decline of fish populations during the last decades. This situation urges the development of a large-scale molecular assessment of Upper Lake ichthyo-fauna to further develop standardized methods of molecular identification for conservation and fisheries management purposes.

Here, we used mitochondrial cytochrome c oxidase subunit 1 (*mtcox* 1) to develop DNA barcode database for fish of Upper Lake. A 615 bases long fragment of the *cox1* gene was sequenced. The genomic DNA were extracted using phenol:chloroform :isoamyl (25:24:1) method. The quality of extracted DNA was determined on a 1% agarose gel. The *cox1* gene fragments were amplified using universal primer (FishF1: TCAACCAACCACAAAGACATTGGCAC and, FishR1: TAGACTTCTGGGTGGCCAAAGAATCA) after the PCR products were visualized by 1% agarose gel electrophoresis under UV light.

We generated 14 distinct DNA barcodes, representing 11 different species belonging to 4 orders, 4 family and 11 genera were barcoded. This research represents the first molecular analysis of Upper Lake ichthyo-fauna. We assembled a consolidated DNA barcode reference library for fish biodiversity of Upper Lake on Barcode Life Data System, USA. The DNA barcoding library turned out to be a highly useful tool for identifying future species and this study provides new insights into the taxonomy.

Endocytosis Restricts Synapse Growth by Attenuating Highwire/PHR1-dependent JNK Signaling in a Pathway parallel to Bone Morphogenetic Protein (BMP) Signaling

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Synaptic growth is a dynamic interplay between multiple processes and signaling mechanisms mediated by pre- and post-synaptic signaling pathways synchronization and synaptic activity. Prior studies have shown that synaptic endocytosis is a key regulator of synaptic growth. Endocytosis is known to regulate one of the central growth-promoting pathways at the *Drosophila* NMJ, the BMP pathway, which involves a retrograde muscle-neuron signaling cascade. However, manipulating the BMP pathway could not suppress these synaptic overgrowth phenotypes, suggesting that multiple signaling pathways are likely to get deregulated in the endocytic mutants. In this context, it is particularly important to understand the various signaling pathways that assist in fine-tuning synaptic growth.

In this study, we investigated the role of autophagy and MAPK signaling in synapse growth signaling in *Drosophila* endocytic mutants. Using *Drosophila* genetics, immunohistochemistry, and high-resolution confocal imaging, we showed that AP2 mutants exhibit reduced autophagy, resulting in accumulation and possible mislocalization of the neuron-specific E3 ubiquitin ligase, Highwire (Hiw)/PHR1, in the neuronal cell body. This accumulated/mislocalized Hiw is non-functional and cannot degrade its downstream substrate, Wallenda (Wnd), leading to elevated JNK signaling. Remarkably, genetically blocking BMP and JNK signaling pathways suppressed the synaptic overgrowth observed in the *σ2-adaptin* mutant to the wild-type levels.

In summary, our study highlights three novel findings linking endocytosis and autophagy in the context of synaptic growth. A) Endocytic mutants show compromised autophagy, leading to the accumulation and mislocalization of the E3 ubiquitin ligase, Hiw, in the neuronal cell body. Accumulated non-functional Hiw causes elevated Wallenda levels, activating the JNK signaling in the endocytic mutants. B) The BMP and JNK signaling are necessary and sufficient to control the mechanisms guiding bouton size and number at the *Drosophila* NMJ. C) The accumulation of Hiw is due to defective Rab11-mediated Hiw trafficking in the endocytic mutants. Endocytosis regulates Rab11-mediated Hiw trafficking and attenuates JNK signaling in a pathway parallel to the BMP signaling to restrict synaptic growth. In addition to its role in synaptic growth, JNK signaling and Hiw trafficking are also linked to the axonal injury response. Our findings on Hiw trafficking and the novel role of endocytosis in regulating JNK signaling will further enhance the understanding of axonal injury response regulation.

Impact of Alcoholism on Thyroid Hormones with Special Reference to Age

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The relationship between thyroid hormones and alcoholism is complex. Alcoholics often experience abnormalities in thyroid function thus thyroid dysfunction is a notable feature in alcoholism, characterized by reduced thyroid hormone levels and altered TSH responses. The present study aims to find the status of thyroid hormones in alcoholism and if there is any relation of this with specific age groups. Understanding these relationships could provide insights into potential biomarkers and therapeutic targets for alcohol dependence.

The present study included 160 participants aged between 20-90 yrs. Blood samples were collected from each participant to measure the levels of Thyroid Stimulating Hormone (TSH), Triiodothyronine (T3) and Thyroxine (T4) using electrochemiluminescence assay and comparisons were made based on demographic variables. The thyroid hormone levels so measured in alcoholics, were then compared to the reference levels. Further alcoholics were divided into 7 age groups and their thyroid hormone levels were analyzed by applying statistical operations.

There was a total of 37.5 % alcoholics who showed deranged thyroid hormone levels amongst which 48 cases were of hypothyroidism and 12 cases were of hyperthyroidism. The mean value of age was 45.75. The highest percentage of alcoholics with deranged thyroid hormones was seen in age group 60-70 yrs. The chi square test gave the statistical value as 21.71 which is greater than the tabulated value of 21.08. This shows that there is a clear association between the level of alcoholic’s thyroid hormones and their age. Thus, it is important for alcoholics to be aware of this negative effect of alcoholism on thyroid hormones, especially with growing age.

Energy Flow in the Lake Ecosystem of Upper Lake, Bhopal: A Comprehensive Analysis

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The Upper Lake ecosystem exhibits dynamic seasonal variations in primary productivity, species composition, and energy transfer. Gross Primary Productivity (GPP) ranges from 1.1 to 2.9 gC/m²/day, peaking during the monsoon (2.8 gC/m²/day) due to nutrient influx and optimal light conditions, while Net Primary Productivity (NPP) constitutes 60–70% of GPP. The phytoplankton community, dominated by *Microcystis aeruginosa*, *Spirogyra sp.*, *Pediastrum boryanum*, and *Anabaena sp.*, fluctuates in abundance across different sites, directly influencing zooplankton density. Zooplankton, including Rotifera, Cladocera, and Copepoda, serve as primary consumers, with assimilation efficiency of 30–40%. Fish diversity is highest during monsoon and lowest in winter, with biomass ranging from 15–40 kg/ha. Herbivorous fish such as *Catla catla* and *Labeo rohita* rely on phytoplankton, while omnivores and carnivores contribute to the trophic structure. Energy transfer efficiency is highest from July to September and lowest in winter. The ecological pyramid reveals a substantial energy loss at each trophic level, limiting tertiary consumer populations. These findings highlight the importance of seasonal dynamics in regulating lake productivity and energy flow, emphasizing the need for conservation measures to maintain ecological balance and sustainability.

Establishment of a Highly Efficient Protocol for Kiwi (*Actinidia deliciosa*) *in vitro* Micropropagation and Secondary Metabolites Accumulation

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The objective of this study was to standardize callus growth and indirect organogenesis from different Kiwi explants. Among the various hormonal combinations tested, the best for inducing callus formation within ten days were Indole Acetic Acid (IAA) with BAP, and IAA with Kinetin. The most effective callus response, leading to green and friable callus, was observed with a 2 mg/l concentration of IAA and 2 mg/l of BAP. The optimal indirect shoot organogenesis was achieved with 1 mg/l BAP and 1 mg/l Kinetin. Rooting occurred in the elongated shoots when placed on half-strength Murashige and Skoog (MS) Medium supplemented with Indole-3-butyric acid (IBA). Among all the concentrations tested, MS medium with 3 mg/l IBA provided the best rooting results, showing the highest percentage of rooting and the most roots. The plantlets produced through indirect organogenesis of kiwi were successfully acclimated to field conditions. To analyze the phytochemicals in the kiwi callus, paper chromatography (PC) and thin-layer chromatography (TLC) were employed, with the bioactive compounds first being extracted from the calli. The compounds were then separated and visualized using appropriate detection methods, enabling the identification of various phytochemicals such as flavonoids, phenolic acids, and carotenoids in the in vitro kiwi callus extract. Further we will be analyzing secondary metabolites using various approaches such as High-performance Liquid Chromatography (HPLC), Gas Chromatography (GC-MS) and Liquid Chromatography- Mass spectrophotometry (LC-MS).

Morphological impact of Neutral Sphingomyelinase-2 (nSMase2) Blocker on Colorectal Cancer Cell Line

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Colorectal cancer (CRC) is a major global health challenge, with disease recurrence being a primary obstacle to patient survival, underscoring the complexity of its metastatic processes at the molecular level. This highlights the necessity of investigating the molecular mechanisms underlying CRC metastasis, which is largely influenced by intercellular communication, particularly through the secretome. Neutral sphingomyelinase 2 (nSMase2) is a key enzyme that regulates ceramide production and exosome biogenesis, and it has been implicated in promoting tumor progression and metastasis. Understanding the morphological changes upon blocking with the nSMase2 blocker is crucial for identifying therapeutic targets and improving outcomes. The study focuses on assessing the visual changes in cell structure and appearance, using tools like microscopy and imaging analysis to document differences in cell shape, size, and surface characteristics between treated and control CRC cells. The findings of this study underscore the pivotal role of neutral sphingomyelinase 2 (nSMase2) in modulating the secretome of colorectal cancer cells. Upon treatment with the nSMase2 inhibitor GW4869, a significant morphological shift was observed, with round-shaped cells constituting 70% of the total population compared to only 30% of elongated cells, indicating a reduction in invasive characteristics. This morphological change, quantified through spindle index calculations, further confirms that nSMase2 inhibition can alter cell shape. Furthermore, the analysis of candidate proteins from the "Vesiclepedia" database reveals their potential involvement in mediating the communication between cancer cells, providing insights into the molecular keystones of metastasis. The study highlights the role of nSMase2 in promoting CRC metastasis through exosome-mediated communication and intracellular signaling modulation, suggesting targeting this gene could potentially mitigate CRC progression.

Exploring the Role of Glutamate Decarboxylase in Acid Stress Resistance in Mycobacteria

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Metabolic adaptations triggered by the host play a vital role in the survival and drug resistance of *Mycobacterium tuberculosis* (Mtb). The ability of Mtb to persist within the acidic environments of phagosomes and phagolysosomes indicates that its initial metabolic adjustments are aimed at countering acidic stress. The glutamate decarboxylase (Gad) enzyme, which converts glutamate into GABA while consuming a proton, is known to aid in pH regulation in other bacteria. However, the presence and function of Gad in mycobacteria remains uninvestigated. Thus, this study aimed to see the presence and function of Gad in mycobacteria and to elucidate its role in survival of Mtb in acidic environment and during intracellular survival within host.

This study aimed to characterize the function of Gad in Mtb. Gad activity was detected in live cells of both Mtb and *Mycobacterium smegmatis* (MS) using Gad assays, TLC, and GABase assays. The *gadB* gene from Mtb was cloned, expressed, and the GadB protein was purified under native conditions using MS as the expression host. Using immunoblotting the expression of gad in Mtb was also detected. Gene expression studies were also performed to investigate the responsiveness of gad-related genes to acidic conditions, reflecting a metabolic shift. Similar gene expression patterns were observed during macrophage infection. To further explore this, we generated an MS *gadA* knockout strain (MSΔ*gadA*) using allelic exchange. In addition, *Mycobacterium bovis* BCG, which lacks native Gad expression, was used to ectopically express gad via the pMV361 vector.
6 × His-GadB was purified using immobilized metal affinity chromatography, with a molecular weight of approximately 51.2 kDa determined by SDS-PAGE. The enzyme was active at both neutral and acidic pH, exhibiting PLP-dependence and optimal activity at pH 7.2 and 50°C. These results suggest *gad* expression in *Mtb* under normal and acidic conditions, supporting a potential Gad-dependent acid resistance mechanism. We observed *gad* gene upregulation in both Mtb and MS under acidic stress and during macrophage infection. The MSΔ*gadA* strain showed reduced survival at pH 3.0, a phenotype rescued by gene complementation, and also exhibited decreased survival within macrophages. Additionally, BCG, which lacks native Gad, showed enhanced intracellular survival when Mtb *gadB* was overexpressed. These findings suggest that Gad plays a crucial role in acid tolerance and intracellular survival, highlighting its potential in host adaptation. Furthermore, our work lays the groundwork for exploring the connection between Gad and antibiotic resistance, suggesting a role for Gad in drug tolerance. These findings open avenues for future research on Gad's role in antibiotic resistance, offering potential for new therapeutic strategies against drug-resistant tuberculosis.

Opportunistic Mating in *Nephila pilipes* Spiders: Avoiding Cannibalism, Ensuring Success

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The giant wood spiders or Golden silk orb-weavers are among the largest spiders with extreme sexual dimorphism with females being much larger than males. Males are at high risk as sexual cannibalism is prevalent especially during mating. In response, males go through elaborate courtship displays that cost them energy and potential life. Competition among males adds more complexity to the mating. The study investigates alternative mating tactics in a web-building spider *(Nephila pilipes*) used by males to maximize their chance of mating with females when they are feeding while avoiding predation risk and ensuring reproductive success. To study opportunistic mating in spiders,we monitored females of the spider *Nephila pilipes* during feeding stage . Male behavior was recorded when approaching and copulating with female. The event was photographed in an attempt to illustrate this adaptive strategy Also the timing in observation of males and females were recorded to evaluate predation risk and opportunities for mating success.In the current study we observed *Nephila pilipes* males court females while they were busy in feeding, minimizing the chances of being cannibalised. These results illuminate an example of male adaptation to high-risk mating environments during reproductive activities such as moulting or feeding in females.The giant wood spiders or Golden silk orb-weavers are among the largest spiders with extreme sexual dimorphism with females being much larger than males. Males are at high risk as sexual cannibalism is prevalent especially during mating. In response, males go through elaborate courtship displays that cost them energy and potential life .Competition among males adds more complexity to the mating. The study investigate alternative mating tactics in a web-building spider *(Nephila pilipes*) used by males to maximize their chance of mating with females when they are feeding while avoiding predation risk and ensuring reproductive success.

To study opportunistic mating in spiders,we monitored females of the spider *Nephila pilipes* during feeding stage . Male behavior was recorded when approaching and copulating with female. The event was photographed in an attempt to illustrate this adaptive strategy in observation of males and females were recorded to evaluate predation risk and opportunities for mating success. *Nephila pilipes* males court females while they were busy in feeding, minimizing the chances of being cannibalised. It enabled males to evade, and effectively mate without competition as far as predation is concerned. These mating strategies under sexual conflict are adaptation of males to minimise female aggression and intermale competition .In *Nephila pilipes* females sometimes mate during their feeding stage when the risk of cannibalism is at its lowest, and the study provided evidence of such behaviour .Such behavior left the male protected from predation while ensuring reproductive success without interference from rival males. These results illuminate an example of male adaptation to high-risk mating environments during reproductive activities such as moulting or feeding in females.

From Floral Market to Pollen Basket: Investigating the Pollination Potential of Indian Honey Bees

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Understanding how pollinators choose which flowers to visit is of fundamental importance in both natural and agricultural ecosystems. The pattern of floral visitation by pollinators directly influences pollen movement and subsequent fruit production. Floral constancy—the tendency of pollinators to sequentially visit flowers of a single species despite the availability of others, is a key aspect of pollinator behaviour. This behaviour enhances cross-pollination and promotes plant reproductive success. In this study, we investigated the foraging behaviour of Indian honey bees in a mixed resource landscape surrounded by farmlands. Specifically, we asked: 1) Do native bees show floral constancy? and 2) If so, is it driven by the abundance of flowering species?

The study was conducted in the seasonal herbaceous community at Kaas plateau, Maharashtra. To quantify floral constancy, we observed the foraging sequences of three bee species: *Apis cerana indica*, *A. dorsata*, and *A. florea*. We tracked 1,030 bees for up to 30 consecutive visits within their foraging bout across 40 observation plots with varying floral diversity. We computed the constancy index for each bee based on their visitation transitions. Additionally, we analysed 300 pollen sacs from two colonies of *A. cerana indica* to assess floral constancy within a hive. GLMM analysis was performed to understand how resource abundance within the plots affected the number of constant bees.

Our study shows that Indian honey bees display high floral constancy, with a higher number of bees being constant on the most abundant flowering species within the plots. This highlights the impact of local resource abundance on the adaptive preferences of pollinators. These findings have important implications for landscape management strategies to maintain local pollinator populations year-round. Since floral constant foraging bouts also ensure the deposition of conspecific pollen, this behaviour has significant implications for managed habitats, especially in enhancing crop yield.

Investigating the Phytoremediatory Effects of *Bacopa monnieri* on cypermethrin-Induced Hypothyroidism and Associated Non-alcoholic Fatty Liver Disease (NAFLD) in a Murine Model

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Cypermethrin (CYP) is widely employed in aquaculture and agriculture. It is recognized as a strong endocrine disruptor in organisms. Hypothyroidism is a global problem. It may be caused by metabolic and hormonal dysfunction due to major exposure to insecticides, pyrethroids, and other environmental sources. A recent challenge that has emerged recently is NAFLD, brought on by hypothyroidism. Because there isn't enough research to support the complex and poorly understood etiology, the correlation between hypothyroidism and NAFLD is still up for discussion.
This study aims to investigate how *Bacopa monnieri* phytoremediate against CYP-induced hypothyroidism leads to the development of NAFLD in murine mice.

The experiment was divided into 4 four groups. The control group (CN) was given water and a regular diet without restriction, while the CYP and CYP+BM groups were administered 15 mg/kg bw cypermethrin orally by gavage. The BM group administered 200 mg/kg bw of *Bacopa monnieri*, while the CYP+BM group received co-administration of BM for 28 days.

The findings revealed that substantial changes in the hormone levels (drop in T3 and T4 and rise in TSH), lipid profile, and liver marker enzymes were produced by the CYP-induced hypothyroidism group. The antioxidant enzymes SOD, CAT, and GPx were also significantly reduced, while the level of oxidative markers (LPO, AOPP, and H_2O_2) increased concurrently. On the other hand, metabolism and hepatic cells are impacted by the substantial decline in THR-β receptor expression. NAFLD is caused by fat accumulation in the liver, as shown by an increase in SREBP-1 expression. Also, the expression of associated proteins in mechanistic pathways can be seen. Whereas BM co-administration can phytoremediate CYP-induced hypothyroidism and its associated consequences,

Furthermore, additional research is needed in the future to determine the association between hypothyroidism and NAFLD, as well as the underlying mechanisms.

Thyroid function tests should be done regularly in all patients with liver disease to reduce morbidity and mortality.

Fish Growth Performance Using Biofloc Technology: A Sustainable Approach

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Biofloc Technology (BFT) has demonstrated superior performance over conventional pond systems in terms of fish growth, feed efficiency, and environmental sustainability. Fish raised in BFT exhibited a 30% higher weight gain and a significantly lower Feed Conversion Ratio (FCR) of 1.2 compared to 1.8 in traditional systems, indicating improved feed utilization. The microbial community in biofloc effectively controlled ammonia and nitrate levels, maintaining optimal water quality without frequent water exchange. Stable dissolved oxygen (DO) levels reduced fish stress, leading to higher survival rates (85–95% in BFT vs. 70–80% in ponds). Additionally, BFT significantly reduced water consumption and feed costs by supplementing natural microbial protein, while also minimizing nutrient discharge, making it an eco-friendly approach. The economic advantages and sustainable nature of BFT highlight its potential for improving aquaculture productivity and food security. Further research is needed to optimize biofloc composition for different fish species to maximize its benefits.
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Mathematical & Computational Modeling of Coinfection Dynamics Under Environmental Stressors in Madhya Pradesh

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Coinfections such as TB-COVID-19 and Malaria-Dengue present an extraordinary public health challenge for regions undergoing rapid environmental change. Pollutants and climatic variations along with immunological factors influence host immunity, pathogen survival, and vector transmission dynamics. An unambiguous increase in severity of infections has been linked to pollution (PM2.5, PM10), temperature, and humidity in Madhya Pradesh. Mathematical models that integrate environmental stressors with coinfection dynamics are few. This study develops an SEIIR-C compartmental model incorporating pollution indices, temperature variation, and rainfall changes to analyze how these factors influence the spread and severity of coinfections.

The study uses the CPCB, IMD, and NASA climate and pollution data. The mathematical SEIIR-C model (susceptible-exposed-infected1-infected2-recovered with climate) has incorporated the environmental parameters into the dynamics of the disease transmission. The model is numerically solved in MATLAB, simulating the system of ODEs, so as to determine the impacts that pollution and climate change had on the spread of infections. The sensitivity analysis identified the key environmental factors that drive outbreaks of coinfection.

Simulations show a strong correlation of the levels of air pollution with respiratory coinfection (TB-COVID-19), while the climate variations drive vector-borne diseases (Malaria-Dengue). High PM2.5 doses worsen TB-COVID severity; temperature fluctuations tend to enhance mosquito breeding, resulting in a more intense co-spread of malaria and dengue. Case studies (e.g., spikes in pollution around Diwali, surges in malaria in the post-monsoon season) further demystify the role of environmental stressors. Sensitivity analysis identifies PM10, humidity, and temperature as dominating risk factors, leading to suggestions for targeted pollution control and climate-adaptive health care interventions. Such findings make for cogent testimony for public health planning and epidemic readiness in Madhya Pradesh.

Dual Ratio Type Class of Estimators for the Estimation of Population Mean Using Auxiliary Variable in Simple Random Sampling

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In this article, we introduce a dual-type class of ratio estimators for simple random sampling using information on auxiliary variable, inspired by the estimator proposed by Srivenkaramana (1980) and Kumar Siddiqui (2024). Our goal is to develop efficient class of estimators for population mean. We have derived the bias and mean squared error of the proposed estimator, up to the first degree of approximation. We have derived the optimum condition at which the suggested class of estimators attained the minimum mean squared error. To assess its performance, we compare the MSE of our proposed estimator with that of several existing estimators. From the theoretical analysis, we demonstrate that the proposed dual-type class of estimators exhibits a lower mean squared error compared to some existing alternatives, indicating that it is more efficient. This suggests that the proposed class of estimators provides more accurate estimates for a given sample size. To validate our theoretical results, we have performed a simulation study, which confirms that the proposed estimator consistently outperforms with some existing estimators in terms of efficiency, regardless of whether the study is empirical or simulation-based. These findings provide compelling evidence for the effectiveness of the proposed class of estimators in practical applications.

A Motion Estimation Variational Model based on Non-Local Weight and Marchaud Fractional Order Derivative

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Motion estimation has gained prominence in vision systems due to its numerous applications, including video surveillance, weather forecasting, submarine navigation, object detection, and medical imaging. Therefore, accurately assessing motion in visual data has accelerated research in motion estimation field. Typically, motion estimation is performed utilizing optical flow, which is represented as vector plots and color map flow fields. Thus, the fundamental objective of this work is to integrate global and local optical flow techniques to deliver a robust and dense optical flow that maintains discontinuities. Thus, the non-local weighted variational model, NF-VOF is proposed.

The NF-VOF model employs a non-local weighted variational framework. The brightness constancy assumption forms the foundation, while non-local weights ensure enhanced accuracy by assigning significance to pixel similarity. The NF-VOF model's global aspect includes the overall motion data within the scene, while its local aspect relates to the distinct motion of each entity in the image frame. The integration of global-local characteristics with the Marchaud derivative in the model effectively addresses edge discontinuities and texturing. It also provides significant resilience to outliers. The system equations are solved iteratively using the Gauss-Seidel method, and the model is evaluated on datasets featuring various complexities, including occlusions, shadows, and dynamic textures.

Experimental results reveal that the NF-VOF model effectively preserves motion edges and achieves dense optical flow fields with reduced errors. Compared to existing models, it demonstrates superior performance in minimizing average angular and warping errors across synthetic and real-world datasets. The study underscores the adaptability, and the robustness of the model. Therefore, the NF-VOF model is a significant contribution to motion estimation techniques for complex visual data analysis.

Managing Pest Populations through Harvesting and Additional Food Strategies: A Mathematical Approach

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This study examines the predator-prey dynamics in an agroecosystem, focusing on the effects of harvesting intervention and additional food supply on natural enemies and pest populations. A comprehensive mathematical and numerical analysis is conducted to explore the system's equilibrium points, including trivial, natural enemy-free, and species coexistence states. The study further investigates the emergence of bifurcations, such as saddle-node, transcritical, and Hopf bifurcations, to understand how variations in harvesting rates and additional food influence population stability. Through numerical simulations, the study highlights the impact of harvesting intensity and additional food availability on predator-prey interactions. The results demonstrate that multiple equilibria, their stability, and the occurrence of bifurcations are directly influenced by these factors. Specifically, excessive harvesting or improper additional food provisioning can lead to undesirable ecological outcomes, including pest outbreaks or the extinction of natural enemies. This research provides theoretical insights into biological control strategies, identifying critical threshold values for sustainable harvesting. It also emphasizes the need for a balanced approach in supplying additional food to enhance the effectiveness of pest management programs. The findings suggest that arbitrary choices in these interventions can have unintended consequences, potentially destabilizing the ecosystem by increasing pest populations while driving predators to extinction. Overall, this work contributes to ecological management by offering optimal strategies for integrating harvesting and additional food supplementation. It underscores the necessity of informed decision-making in biological control programs to maintain ecological balance and ensure the long-term sustainability of agroecosystems.

A Neural Network Approach to Solve Partial Differential Equation of Bond Pricing

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Interest rates serve as a compass in financial markets, guiding investment decisions, shaping borrowing costs, and influencing the overall health of economies worldwide, hence capturing the right interest rate accurately becomes paramount. This chapter proposes an innovative framework that uses Physics Informed Neural Networks (PINNs) to price zero coupon bonds and simulate interest rate behavior. Conventional numerical methods, including finite differences and Monte Carlo simulations, often encounter difficulties related to computational efficiency and adaptability. PINNs leverage the expressive power of neural networks by integrating the governing differential equations directly into the training process.

This article emphasizes on the Vasicek model, a pivotal framework for modeling short rate dynamics, recognized for its mean-reverting characteristics and analytical manageability. Building on this framework, the study explores the implementation of Physics Informed Neural Networks to address the bond pricing partial differential equation formulated from the Vasicek model. Utilising data from the U.S. Treasury yield curve, PINNs is trained to model interest rate dynamics by integrating the stochastic differential equation of the short rate into the learning framework. The PINNs architecture is enhanced to price zero coupon bonds by integrating the partial differential equation into the neural network's training process.

The predicted bond prices are rigorously contrasted with analytical solutions to assess the precision and reliability of the PINNs methodology. Numerical experiments are performed to assess the convergence and stability of the PINNs predictions under diverse conditions. To enable a comprehensive assessment, suitable error metrics are utilized to quantify the differences between the outcomes derived from PINNs and the analytical solutions. Finally, the article concludes with an analysis on the prospective scope of research, highlighting the possibility for extending the use of Physics Informed Neural Networks to a wider array of financial instruments.

Mathematical Modelling the Effect of Pollutants in a Three-species Food-chain Model by Considering Distributed Delay

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Mathematical modelling plays a crucial role in understanding ecological systems by providing insights into population dynamics and stability conditions. In this study, we develop and analyse a three-species ecological model incorporating interactions between species, resource control mechanisms, and environmental constraints. The primary objective of this research is to determine the existence of ecological species in the presence of polluted environment by considering distributed delay.

The proposed mathematical model is analysed by using a system of nonlinear differential equations representing interactions between predator, prey, and resource dynamics. Mathematical techniques such as Lyapunov stability analysis, Jacobian matrix evaluation, and eigenvalue computation are employed to study local and global stability. Additionally, numerical simulations are performed using MATLAB to validate theoretical findings and explore the impact of parameter variations on the ecological species behaviour.

The analysis confirms the boundedness of solutions, ensuring biologically feasible dynamics. The existence and stability of multiple equilibrium points are established, with conditions determining species persistence or extinction. Local stability is assessed through eigenvalue analysis, while a suitable Lyapunov function verifies global stability. Numerical simulations illustrate the impact of ecological parameters on system stability, revealing potential bifurcation phenomena. Numerical simulations further validate theoretical results and demonstrate the influence of ecological parameters on system behaviour. The study's findings contribute to ecological modelling, offering implications for biodiversity conservation and sustainable resource management.

The Study of Top Predator Interference on Tri Species with "Food-Limited" Model under the Toxicant Environment: A Mathematical Implication

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Mathematical modeling plays a crucial role in understanding ecological systems by providing insights into population dynamics and stability conditions. In this study, we develop and analyze a non- linear mathematical model to explore the impact of top predator interference on the three species of the marine food chain system, incorporating the growth of "food-limited" prey populations under the toxic effect The primary objectives of this research are to establish the boundedness of solutions, determine the existence of equilibrium points, and investigate their stability properties. The study aims to contribute to ecological conservation strategies by identifying conditions for species coexistence and system sustainability.

The proposed model is analyzed using a system of nonlinear differential equations representing interactions between four state variables: prey density, intermediate predator density, top predator density, and environmental toxicant. Mathematical techniques such as Lyapunov stability analysis, Jacobian matrix evaluation, and eigenvalue computation are employed to study local and global stability. The existence of equilibrium points is determined by solving algebraic equations derived from the system. Additionally, numerical simulations are performed using MATLAB to validate theoretical findings and explore the impact of parameter variations on system behavior.

The analysis confirms the boundedness of solutions, ensuring biologically feasible dynamics. The existence and stability of multiple equilibrium points are established, with conditions determining species persistence or extinction . Global stability has been verified by a proper Lyapunov function, while local stability is evaluated using eigenvalue analysis. Numerical simulations illustrate the impact of ecological parameters on system stability. These findings provide valuable insights into ecosystem management, conservation planning, and the effects of external perturbations on ecological balance.

Construction of Post Quantum Secure and Efficient Authenticated Key Exchange Protocol for Mobile Devices

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Mobile applications have become increasingly popular as a result of recent advancements in wireless technologies, which allow users to access a variety of web services from anywhere at any time. Because the communication channel is fundamentally public, it is now crucial to provide security in wireless communications. To ensure secure communication, cryptographers have developed a variety of authentication systems for mobile devices during the last 20 years.

These schemes usually follow a two-party or three-party scenario. Many of these approaches, however, rely on discrete log (DLP) or factorization (IF) number-theoretic hard problems, which can be effectively solved on a highly scaled quantum computer by applying Shor's algorithm. Therefore, in post-quantum environments, authenticated key exchange (AKE) protocols relies on the difficulty of these mathematical problems are rendered insecure.

Analyzing and constructing AKE protocols that can be adopted in quantum environment is therefore critically required. In this research, a novel quantum secure AKE mechanism based on the Ring Learning With Error problem is proposed for mobile devices. The proposed protocol is resistant to key mismatch attack, user impersonation, known session key attacks, replay attacks, privileged insider attacks, men in the middle attacks, and offline password guessing attacks. The proofs for resistance are demonstrated in the article. Additionally, the proposed design's thorough analysis and security establishment are provided within random oracle model. Also, forward secrecy is achieved in the proposed design. To determine the proposed design's practical efficiency, the paper also presents a comparison analysis and performance evaluation.

An Efficient and Probably Secure Multivariate Hierarchical Identity-Based Signature Scheme using Isomorphism of Polynomials Problem over Finite Fields

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Multivariate Public Key Cryptography (MPKC) is a leading candidate for Post-Quantum Cryptography (PQC), leveraging the NP-hardness of solving Isomorphism of Polynomials (IP) problem and solving systems of Multivariate Quadratic (MQ) equations over finite fields to ensure robust security against quantum attacks. Over the past two decades, significant advancements in MPKC have led to highly efficient signature and encryption schemes, making it a practical solution for securing modern communication systems in the quantum era.

In this work, we propose a first Multivariate Hierarchical Identity-Based Signature (M-HIBS) scheme based on the hardness of the Isomorphism of Polynomials (IP) problem, offering a post-quantum solution for secure and efficient identity-based signatures. Our scheme leverages the efficiency of multivariate cryptography and employs a specialized variant of non-interactive zero-knowledge proofs of knowledge (NIZK), specifically the signature of knowledge (SoK), to ensure secure key delegation and signature generation. The M-HIBS scheme achieves existential unforgeability against chosen message attacks (EUF-CMA) and chosen identity attacks (EUF-CIA) in the random oracle model (ROM), with security relying on the NP-hardness of the IP problem, making it resistant to quantum attacks.

A key advantage of our scheme is its computational efficiency as compared to other existing post quantum HIBS. Compared to existing multivariate identity-based signature schemes, M-HIBS significantly balances the security and efficiency, making it ideal for resource-constrained environments such as IoT devices and smart cards, blockchain, etc. The hierarchical structure enables efficient key delegation and management, addressing scalability challenges in large-scale systems.

Generalized Fagnano Problem for Convex Sets: Optimality Conditions and Algorithms

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Geometry has always fascinated mathematicians with its beauty and challenging problems. One such problem is Heron's problem, where the goal is to find a point on a line that minimizes the total distance to two fixed points. Later, new problems like the Fermat–Torricelli point problem and the Fagnano problem were introduced, leading to more studies in geometric optimization. Building on these ideas, this paper presents a new generalization of the Fagnano Problem. Instead of using the vertices of a triangle, we replace them with convex sets, making the problem more practical for real-world applications.

We prove that the generalized Fagnano problem has a solution and derive necessary and sufficient conditions for finding the optimal solution. To find the approximate solution, we used the projected subgradient descent algorithm and improved its speed with Aitken acceleration for faster convergence.

Finally, we illustrate the algorithm with numerical examples, such as considering convex discs and spheres. These examples show that our method not only solves the problem effectively but also converges faster than other approaches. This research provides a new way to solve distance-minimization problems and offers tools useful in areas like robotics, network design, and geometry.

Optical Flow and AI-Driven Smoke Detection and Segmentation for Fire Prediction

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Fire breakouts are a serious threat to human life and property around the world. Fire breakouts can start from a variety of sources, such as electrical faults, cooking mishaps, natural disasters, or human negligence. Fire breakouts are extremely unpredictable and can quickly spiral out of control. In order to prevent these fire breakouts, digital video (image sequence) based computer vision and deep learning techniques for fire detection have emerged as key technologies.

The objective of this work is to develop an uncertainty-aware Swin Transformer for robust segmentation and create a smoke segmentation dataset for fire prediction. In order to construct the dataset, smoke motion in RGB images is represented using optical flow color maps, which mitigate the illumination changes and background noise. The optical flow estimation is formulated via a dual-phase level set-driven fractional-order variational model, preserving smoke motion discontinuities.

The estimated color maps serve as input to a Gaussian Mixture Model, which probabilistically segments smoke regions from the background elements and generates the binary masks. The uncertainty-aware Swin Transformer incorporates a multi-scale uncertainty estimation head, enhances the robustness against the non-stationary nature of smoke plumes, and improves generalization across diverse environmental conditions. The uncertainty-aware Swin Transformer is trained on the smoke segmentation dataset to segment and detect the existence of smoke. This deep learning approach enables real-time inference while ensuring high accuracy. The framework achieves high segmentation accuracy, effectively distinguishing smoke from background noise. The validation of the proposed algorithm is established by comparing it against various state-of-the-art approaches. The significance of each module of the developed framework is supported through an ablation study. Also, different accuracy metrics are considered for performance evaluation.

A Modified Differential Evolution Variant for Economic Dispatch Optimization

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In the area of energy management and optimization, economic dispatch (ED) has received considerable interest. Its main goal is to attain the least power dispatch cost, abiding by all physical constraints. In recent decades, metaheuristic algorithms (MAs) have become the dominant approach for resolving ED problems because of their ease of application and powerful search capability. Among them, differential evolution (DE) consistently demonstrated significant effectiveness and produced the best results on various optimization problems. It has been employed in multiple domains owing to implementation ease, robustness, and considerable convergence speed. However, DE is not more successful in escaping the local optimum trap (i.e., insufficient exploration and excessive exploitation) when solving challenging optimization issues. To address these limitations and solve ED problems effectively, this paper introduces a modified DE (called mDE). It involved – (i) a different mutation scheme (by the theory of the particle swarm optimization) through new control factors to preserve exploration precision, (ii) an altered crossover rate to advance exploitation ability, and (iii) an inventive selection system, to proportionate diversity and evasion from the local minima. The presentation of the offered mDE process is assessed on 13 standard test problems. Furthermore, the four cases of ED problems (3, 6, 15, and 40-unit systems) should be optimized to prove the practicality of mDE. All experimental investigations confirm the superior performance of the proposed mDE relative to the compared procedures in terms of faster convergence, reasonable solution superiority, and computational effort.

An Algebraic Approach Towards a Conjecture on the Davenport Constant

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For a finite multiplicative group G, the invariant *ordered Davenport constant* D(G) is defined as the least positive integer k such that for every sequence $S = g_1 \bullet g_2 \bullet \ldots \bullet g_k$ of length k over G, there exist distinct indices $1 \leq i_1 < i_2 < \ldots < i_r \leq k$ for which $g_{i_1} g_{i_2} g_{i_3} \ldots g_{i_r} = 1$, where 1 is the identity element of G. The *small Davenport constant* d(G) is the maximal positive integer k such that there is a sequence of length k over G which has no non-trivial product-one subsequence. In this article, we compute D(G) for certain classes of finite non-abelian p-groups, including metacyclic groups for any prime p and prove that for specific classes of groups, D(G) = d(G)+1.

In 2004, Dimitrov proved that D(G) ≤ L(G) for a finite p-group G, where L(G) is the Loewy length of $\mathbf{F}_p[G]$. He conjectured that the equality holds for all finite p-groups. To determine the exact value of D(G), we calculate the precise value of L(G) and give a tight lower bound on D(G). For some cases, a sequence that provides a tight lower bound on D(G) shows the equality with d(G)+1.
Through this approach, we prove Dimitrov's conjecture for infinitely many p-groups and refine the upper bound on d(G) for these groups, as recently given by Qu, Li and Teeuwsen. An important feature of the invariants D(G) and d(G) is their application in primality testing, particularly in cryptography, where Fermat's Little Theorem is used. Initially, Fermat's Little Theorem was effective as a primality test, but it was later demonstrated with the help of the Davenport constant that there are infinitely many composite numbers that also satisfy the theorem. These numbers, known as pseudoprimes or Carmichael numbers, challenge the reliability of the test. By establishing a tight upper bound on D(G) for abelian groups, a more accurate approximation of pseudoprimes can be achieved. These combinatorial invariants have applications across various fields, such as number theory (including algebraic number fields and Artin additive forms), invariant theory (e.g., Noether numbers), graph theory (such as zero-sum Ramsey numbers), and cryptography (in areas like error-correcting codes).

Infectious Disease Effects on Harvested Prey- Predator Dynamics

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A constant expansion of research has been carried out on models incorporating prey-predator and contagious diseases where infected prey plays a crucial role in eco-epidemiological systems investigating a prey-predator model with disease in prey and harvesting in prey and predator populations with a functional response of Holling type-II. Spread of disease during prey harvesting by predators and the assumption that the predators hunt on the prey, a mathematical model has been proposed for a predator-prey system and prey population with a contagious disease.

The analysis reveals that the system has five types of equilibrium: trivial, healthy prey survival, predator-free, infection-free and endemic. Among these trivial equilibrium always exists in unstable mode while the local stability of the remaining equilibriums depends upon the parameter conditions.

Moreover, existence and stability are evaluated in light of the basic reproduction number around the axial and interior steady state. According to ecosystem parameters, the proposed system also experiences transcritical and Hopf bifurcation. Finally, we have performed the numerical simulation to justify the analytical results obtained in the aforesaid model.

Efficient Classes of Nordsieck General Linear Method with Quadratic Stability Function

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Many real-world problems arising in engineering, especially in mechanics, are stiff problems and can be modeled by large systems of ordinary differential equations. While these kinds of problems can be solved by existing numerical solvers in the literature, they often fail to be as efficient as expected, requiring very small time discretization steps and resulting in higher CPU times. In the age of modern computing, there is a very high demand for the development of numerical solvers that can handle real-world problems efficiently, achieving higher accuracy in relatively less time.

This article introduces a class of L-stable solvers specifically designed to address highly stiff problems without requiring extremely small step sizes or excessive refinement of the time grid with an overly large number of subintervals. We present three classes of implicit GLMs of order (p = 1, 2, 3) with quadratic stability functions. These methods are formulated to ensure stability and accuracy while minimizing computational effort.

Numerical illustrations are provided for stiff differential equations used to model various real world phenomena. We have applied our algorithms to three different problems, including Prothero-Robinson problem, van der Pol system and time dependent differential system arising after spatial discretization of Burgers equation using MOL (method of lines). The results indicate that our proposed classes perform well, with their effective order matching the observed order of accuracy. We have also given error versus step size plots to show the convergent behaviour of the proposed numerical solvers. These findings demonstrate that no order reduction has been reported, highlighting the robustness and potential utility of the proposed methods in solving real-world stiff problems efficiently.

A Fuzzy Based Approach to Enhancing Software Reliability Prediction by Incorporating Latent Diversity

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In software testing, factors such as hidden faults, user expertise, varying debugging efficiency, interaction patterns, and diverse operational environments are collectively called latent diversity. These factors significantly influence software reliability. However, traditional software reliability growth models (SRGMs) often overlook these factors, resulting in space in reliability prediction. While testers attempt to address these variations during testing, their impact on overall reliability estimation remains insufficiently explored. This study aims to bridge this space by enhancing SRGMs by explicitly incorporating latent diversity, thereby improving the accuracy of reliability assessments.

For this purpose, the development of an SRGM is suggested with a variable that accounts latent diversity effects. This variable is stated to be a Gamma random variable, which precisely corresponds to the characteristic variation and skewness of the reliability effects. The model parameters have been estimated using the least square estimation (LSE) method. Moreover, fuzzy set theory addresses the issue of uncertainty and imprecision inherent in these parameters, thus, producing more realistic conjunctions of tests. For instance, trapezoidal fuzzy numbers (TrFNs) have been used in this work to illustrate the imprecision accompanying latent diversity and achieve the computational efficiency required in potential uncertainty quantification.

The comparative analysis shows that the proposed model is more reliable than the conventional SRGMs. The results epitomize that the proposed model has less error than the existing one. Adding latent diversity with fuzzy set allows for better estimation and prediction of reliability. Such able characteristics of this new model will enhance the decision-making process of software engineers and testers during the testing and maintenance activities. By addressing previously unaccounted for variations, this study contributes to developing more realistic and reliable software reliability models, ultimately improving software quality and performance.

Machine Learning Approach For Predicting Option Price

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Artificial intelligence has become more and more popular in the finance sector in modern era. Calculating the price of an option is thought to be one of the trickiest financial problems. It's accuracy and profitability could be greatly increased by using machine learning models, especially when combined with huge amounts of high-quality data and cautious validation and interpretation. In contrast to traditional parametric methods, non-parametric approaches for pricing options have been found to offer higher prediction quality and need less computing time.

This study compares two machine learning models, Random Forest (RF) and Support Vector Regression (SVR), to predict the closing prices of the National Stock Exchange FIFTY (NIFTY 50) index. The data model was developed using features from the 2019 year, which covered 52 companies' Nifty-50 indices of the Indian stock market. To assess the pricing performance of the model and the precision of the methods used, we employed five different measures to forecast errors: MAE, MSE, RMSE, MAPE, and R-Squared.

The study provides with an overview of the most widely used regression models. We have dominant features which gives a representation of how the stock market behaves. For pricing European-style options, the experimental findings demonstrate that machine learning models—like the random forest—perform better with sufficient precision also high prediction accuracy and excellent fit is offered by the RF model design. By demonstrating that even basic machine learning models could be competitive substitutes for the conventional parametric approaches to stock option pricing. Derivatives are a powerful tool in the financial world that can help manage risk, enhance returns, and improve market efficiency. The pricing of options reflects market expectations about future asset prices and volatility. ML models can help financial institutions and investors better understand and manage their exposure to risk by providing more accurate pricing estimates.

Effects of Halloysite Nanotubes in Electrospun PAN Separator for Sodium-Ion Battery Application

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Sodium-ion batteries (SIBs) represent a promising next-generation energy storage technology poised to replace lithium-ion batteries (LIBs) due to their cost-effectiveness and abundance of sodium resources. Separators are indispensable for the performance, safety, and longevity of batteries, acting as a ionically conducting but electronically insulating membrane. Electrospinning is the best approach to produce highly porous yet mechanically robust separators.

In this study, a nanocomposite separator composed of electrospun poly acrylonitrile (PAN) and Halloysite nanotubes (HNTs) was developed and evaluated for its potential use in SIBs. The electrochemical properties of the HNT incorporate PAN based gel polymer electrolyte (GPE) were assessed using techniques such as linear sweep voltammetry, electrochemical impedance spectroscopy and half-cell characterization.

The decreased crystallinity, increased porosity and high electrolyte uptake of the non-woven PAN/HNT composite contributed to higher ionic conductivity (1.62 mS/cm) and facilitated ionic transport across the separator. The composite demonstrated a high electrochemical stability window of 5.1 V and excellent interfacial compatibility with sodium metal. A sodium-ion cell using the NFM111 cathode, PAN/HNT separator, and sodium anode delivered an initial specific capacity of 152 mAh/g with a coulombic efficiency of 94.2 %. Remarkably, the cell exhibited stable cycling performance with a capacity retention of 78 % after 100 charge-discharge cycles. Compare to a pure PAN separator, the PAN/HNT composite exhibited superior ionic conductivity and discharge capacity, highlighting the synergistic benefits of integrating HNTs into the polymer matrix. These findings demonstrate the potential of PAN/HNT nanocomposites as robust and efficient separators facilitating the development of sustainable and scalable energy storage technologies.

Circular Supply Chain Management & Indian MSMEs: Analysis of Barriers Using DEMATEL Approach

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Indian Micro, Small, and Medium Enterprises (MSMEs) are the most crucial sector of the nation's economic structure and are also responsible for huge amounts of waste production. This waste can be reduced to zero by the adoption of circular economy principles in the entire supply chain. This zero-waste approach is known as Circular Supply Chain Management (CSCM). However, MSMEs face various barriers to the adoption of such circular practices. Hence, the study aimed to identify and analyze those critical barriers to the CSCM in Indian MSMEs.

The study adopted a mixed-method approach. A qualitative approach of literature review and expert opinion is used to identify the critical barriers. Further, a quantitative analysis is done using the Decision Making Trial and Evaluation Laboratory (DEMATEL) method. This method analyzes the interrelationships and causal relationships among the identified barriers along with their ranking and influence.

The study highlights the key barriers to the implementation of CSCM. The 'Inadequate legal framework in India' and 'Organizational Restraints' are the prominent causes. 'Lack of Adequate Infrastructure', 'Economic Barriers', and 'Challenges with Human Resources in Enterprize' are also the cause barriers affecting CSCM in MSMEs. The study significantly impacts all supply chain stakeholders. Policymakers, practitioners, and researchers benefited substantially from its findings. The dynamics among the barriers help MSMEs to focus on the thrust areas of improvement for circular goals. The findings help policymakers foster economic growth and sustainability by supporting the specific needs of MSMEs. Researchers have the opportunity to explore other dimensions of CSCM and MSMEs.

Development of Enhanced Triboelectric Nanogenerator based Machine Skin for Condition Monitoring of Legacy Machines: A Customised Tool towards Industry 4.0

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This work presents the development of Machine Skin, an array of self-powered IoT-enabled Triboelectric Nanogenerator (TENG)-based vibration sensors. In that concern, the electrical output of these sensors must be enhanced followed by integration of energy harvesting module and IoT modules.

Low-pressure air plasma treatment was done on Fluorinated Ethylene Propylene (FEP), to obtain maximum enhancement in electrical output of TENG, to make it self-powered sensor. The Plasma Treated-TENGs (PT-TENG) were mounted on the hydraulic power pack, IoT module was integrated for real-time data transfer, and vibration analysis for condition monitoring.

The formation of Machine Skin provides a customized solution for condition monitoring of legacy machines in Industry 4.0 paradigm. Plasma treatment of FEP leads to 226% and 295% boost in the open-circuit voltage and short-circuit current of TENG generating 548 V and 79 µA, respectively. This results from ion bombardment during plasma treatment, which creates active sites for charge transfer. PT-TENG was integrated with an energy harvesting module to charge 100 mAh battery to power IoT module. Integration of IoT module with self-powered TENG, enables transfer of voltage signals produced by the TENG corresponding to the vibration generated by machine, forming Machine Skin. Two PT-TENGs were mounted on hydraulic power pack-integrated piston-cylinder, one on the inductor motor and another on the piston-cylinder. PT-TENG on the inductor motor was able to detect the working state and vibration frequency of inductor motor, while PT-TENG on the piston-cylinder was able to detect the motion of the piston and the loading condition by analyzing the voltage signal generated by the TENG corresponding to the vibration generated. These results were displayed on the dashboard over smart devices.

Numerical Simulation and Experimental Correlation of Tube Bulging by Magnetic Pulse Forming

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Tube bulging/forming is widely used metal forming process for shaping tubes into complex geometries through controlled deformation. Traditional methods, such as hydraulic, pneumatic, and vacuum-assisted bulging, often require expensive tooling, high operational cost, longer processing times, and elevated temperatures that can alter material properties.

In contrast, Magnetic Pulse Forming (MPF) provides a high-speed, non-contact alternative that utilizes electromagnetic force to shape conductive materials efficiently. MPF operates by discharging electrical energy through a coil, generating Lorentz forces that induce high-velocity deformation without mechanical contact or external heating.

This study explores the application of MPF for bulging Al6061 tubes, focusing on the effects of varying discharge energy (11 kV, 13 kV, and 15 kV with a two-bank capacitor system) to achieve desired deformation. Finite Element (FE) simulations provide a cost-effective and efficient approach to modeling dynamic deformation and performance of tooling. By accurately predicting deformation before experimentation, they minimize trial-and-error, enhancing product quality and process efficiency. Finite element simulations using LS-DYNA with an axisymmetric 3D model are carried out to predict process parameters, including magnetic fields, velocities, Lorentz forces, current density and displacement. The simulated results are correlated against experiments and confirming the accuracy of the modeling approach. The findings highlight MPF of tube, such as reduced thermal effects (no heat affected zone), minimal tooling requirements, and good formability of metals at different discharge energies. Additionally, precise energy control in MPF improves process efficiency, material integrity and reduce localized thinning of tube material. This research contributes to advancing MPF as a viable alternative for tube forming/bulging in manufacturing sector, with significant potential applications in the automotive, aerospace, and engineering industries.

Rationally Designed Mechanically Robust Multilayer System Enabling Surface Protection and Lubricity

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Material deterioration, impaired functionality and performance, premature failure, and environmental degradation are the adverse impacts on mechanical components when they are exposed to rigorous conditions in many applications including industrial machinery, aerospace, automotive sector, marine and offshore structures, and infrastructure.

To address these concerns, we deposited monolithic hydrogenated amorphous carbon (a-C:H) and Cu interlayers assisted a-C:H multilayer coatings using PECVD tool. Potentiodynamic polarization tests were performed to probe the corrosion resistance behaviour of these coatings on stainless steel (SS304) and mild steel (MS) substrates, and the obtained results revealed the excellent corrosion resistance of Cu interlayered a-C:H multilayer coatings, with a reduction in the corrosion rate of SS304 by up to 250 times. Ball-on-disk tribological tests were performed to investigate the friction and wear characteristics of these coatings, and the obtained results demanded crucial improvement. So, we further modified all the surfaces with a binary composite of multilayer graphene and multi-walled carbon nanotubes (i.e. GCNT composite) to achieve superior tribological characteristics.

The composite synergistically alters the sliding interfaces and thereby exceptionally reduces the friction (by 60% - 85%) and wear of diverse underlying surfaces. This work presents an innovative approach to produce surfaces that are both lubricious and offer protection against wear and corrosion, via combined chemical modification and materials engineering effects which is crucial for fundamental science as well as technological advancement.

An Ultra-narrow Gap Joining Process for Dissimilar T/P92 and AISI304 Steel

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The creep strength enhanced ferritic-martensitic (CSE F/M) T/P92 steel and AISI 304 austenitic stainless steel are extensively used in the power and petrochemical industries due to their superior thermos-physical, mechanical and metallurgical properties and high-temperature performance. However, their distinct properties, such as differences in chemical composition, thermal expansion and microstructure, present challenges in achieving strong and defect-free welds. This study aims to develop a reliable ultra-narrow gap welding process to join these dissimilar materials, focusing on minimizing intermetallic phase formation and thermal stresses at the weld interface. The goal is to improve weld strength, ductility, and creep resistance, while optimizing process parameters to ensure performance under extreme industrial conditions.

The ultra-narrow gap welding process via Pulse-GMAW utilizes T/P92 ferritic-martensitic steel and AISI 304 austenitic stainless steel as base metals, with ER308L filler wire to minimize intermetallic phase formation. Argon shielding gas stabilizes the arc and enhances penetration. Base metals are cleaned and machined with an ultra-narrow groove (<7.5 mm) for precise alignment. Optimized Pulse-GMAW parameters-controlled heat input, reduce thermal stresses, and ensure uniform heat distribution. Interpass temperatures are kept at room temperature to prevent cracking, with welding performed horizontally in multiple passes.

Microstructural analysis using optical microscopy was performed to assess fusion quality and phase transformations in the welding process. The results show excellent fusion between T/P92 and AISI 304 steels, with minimal defects like porosity and cracks. A refined heat-affected zone (HAZ) with reduced width was observed due to controlled heat input, and the formation of detrimental intermetallic phases was minimized by optimizing pulse parameters. The narrow groove and Pulse-GMAW process ensure efficient material use, reduced distortion, and precise weld geometry. This study offers a cost-effective, reliable solution for joining dissimilar metals in industries like power generation, enhancing equipment performance and safety.

AI-Enhanced Fluorescent GQD Nanocomposites for Arsenic Detection

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The rising levels of arsenic in drinking water pose significant health risks globally, necessitating the development of efficient detection methods. This study focuses on the synthesis and application of AI-enhanced fluorescent graphene quantum dot (GQD) nanocomposites for sensitive and selective detection of arsenic in aqueous environments. To achieve this, we synthesized GQD nanocomposites using a one-pot hydrothermal method, followed by functionalization to enhance their fluorescent properties. The detection process involved the addition of various concentrations of arsenic to the GQD solution, with fluorescence intensity measured using a fluorescence spectrophotometer. AI algorithms were employed to analyse the fluorescence data, optimizing the detection limits and response times. The findings reveal that the AI-enhanced GQD nanocomposites exhibited a significant increase in fluorescence intensity in the presence of arsenic, demonstrating a linear response over a wide concentration range. The detection limit was found to be as low as 0.1 ppb, surpassing many conventional methods. This innovative approach not only enhances the sensitivity of arsenic detection but also provides a rapid and cost-effective alternative for field applications. The integration of AI in analysing fluorescence data represents a paradigm shift in environmental monitoring technologies, establishing a new benchmark for future research in nanocomposite applications. This work underscores the importance of developing advanced materials for environmental safety and public health, offering a promising solution to combat arsenic contamination in water sources.

High-Performance Shape-Memory Polyurethane Composites: Tribological Enhancements with MAX and MXenes

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Stimuli-responsive materials, such as shape-memory polymers (SMPs), have broad applications in robotics, aerospace, biomedical engineering, and artificial intelligence. Despite their versatility, SMPs exhibit complex sliding properties, leading to unconventional friction and wear behavior, which limits their long-term durability. This study aims to improve the sliding properties and wear resistance of shape-memory polyurethane (PU) by incorporating titanium carbide-based fillers, specifically the Ti_3AlC_2 (MAX) and Ti_3C_2 (MXene) phases, to develop high-performance polymer composites.

PU composites were developed via melt mixing using a micro-compounder followed by injection molding. The tribological performance of pristine PU, PU-MAX, and PU-MXene composites was evaluated using a ball-on-disk tribometer under controlled conditions. Optical surface profilometry was used to measure the depth of wear tracks. Additionally, Raman spectroscopy was utilized to analyze tribochemical interactions and phase transformations occurring during the sliding process, shedding light on the underlying friction and wear mechanisms.

The composites showed a 2–3x reduction in the coefficient of friction and significantly enhanced wear resistance, even with as little as 0.25 wt.% filler. Surface profilometry confirmed a marked decrease in wear track depths, while Raman spectroscopy indicated tribochemical reactions and the formation of a protective TiO_2 layer, further improving wear resistance. Considering the properties enhancement extent and ease of synthesis, the MAX phase materials could be preferred over MXenes as reinforcing agents for polymer composite developments, especially for shape memory PU composites. Overall, MAX and MXenes are promising foreign materials that can exceptionally boost the characteristics of SMPs, paving the way for their integration into next-generation smart technologies and high-performance engineering applications.

Investigating the Burden of Infectious Agents in cases of Adverse Pregnancy Outcome in A Tertiary Healthcare Unit using In-House Developed Real Time PCR assay

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This study represents an ongoing exploratory investigation into the burden of pathogens in cases of stillbirths and miscarriages with unidentified etiologies. Adverse pregnancy outcomes are reported in approximately 10–15% of all pregnancies, of which 15–20% remain without a definitive cause. The role of infectious agents and their exposure levels in cases of stillbirth, miscarriage, neonatal sepsis, or congenital anomalies requires further detailed exploration.

A Laboratory-Developed Assay (LDA) utilizing real-time reverse transcription polymerase chain reaction (RT-PCR) was utilized to screen 87 samples collected from 63 cases admitted to AIIMS Bhopal and GMC Bhopal, India. Total nucleic acids were extracted, followed by real-time RT-PCR to detect *Brucella spp*., *Coxiella burnetii*, *Listeria monocytogenes*, Hepatitis E virus, Human Parvovirus B19, Cytomegalovirus (CMV), Epstein Barr virus (EBV), and Enterovirus. The results were validated through an in vitro diagnostic assay (IVD) and confirmed via Sanger sequencing.
Total 63 cases (19 miscarriage, 5 stillbirth and 39 neonatal sepsis) comprising of 87 samples (24 maternal blood, 24 maternal urine, 37 neonatal blood and 2 neonatal cerebrospinal fluid) have been screened. The highest overall positivity in cases of early miscarriage is of Brucella (19.23 %), Human Parvo B19 (11.53 %), Enterovirus (3.85 %), CMV (3.85 %), EBV (3.85 %) and HEV (3.85%); in cases of stillbirth is of Brucella (10 %), Enterovirus (20 %) and in cases of neonatal sepsis is of Human Parvo B19 (15.38 %), Enterovirus (7.69 %), Listeria (5.13 %) and CMV (2.56 %). The findings from the LDA were consistent with those obtained using IVD. Clinical presentations reported in the cases of miscarriage and stillbirth included abdominal pain, cessation of fetal cardiac activity, and spontaneous bleeding, with no clear etiology. The clinical presentation in cases of neonatal sepsis was preterm birth and low birth weight. These findings underscore the need for effective surveillance and differential diagnosis of pathogens associated with adverse pregnancy outcomes, particularly in tropical regions. Pregnant women may serve as asymptomatic or subclinical reservoirs of infectious agents. The immunosuppressive state during pregnancy and differential effects of infectious agents potentially masked by physiological or underlying disorders require focused investigation to mitigate the recurrence of these outcomes.

Evaluating the Clinical Utility of Hematological Ratios in Sickle Cell Anemia

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Sickle Cell Disease (SCD) is a genetic blood disorder that affects the shape and characteristics of red blood cells. It can manifest a range of symptoms characterised by chronic hemolytic anaemia, recurrent infections, acute pain crises, and organ damage that vary in severity and frequency among individuals. In Indian tribal populations, it is a significant contributor to obstetric problems and pregnancy risk. Neutrophil to Lymphocyte Ratio (NLR), Platelet to Neutrophil Ratio (PNR) and Platelet to Lymphocyte Ratio (PLR) are the two important biomarkers derived from blood tests that can provide insights into the clinical severity of SCD patients. This study understands the potential clinical utility to determine NLR, PNR and PLR in SCD patients.

Three hematological ratios were calculated for each patient: NLR, PLR, and PNR. NLR was derived by dividing the absolute neutrophil count by the absolute lymphocyte count. Similarly, PLR was obtained by dividing the platelet count by the absolute lymphocyte count, and PNR was calculated as the ratio of the platelet count to the absolute neutrophil count.

The NLR and PLR ratios was found significantly higher in patients than controls, suggesting that enhanced NLR is linked to anaemia. While, PNR ratio was found significantly lower in patients than controls. The NLR, PNR and PLR values may be useful as prognostic markers in SCD patients. Although the genetic and molecular underpinnings have long been identified, the pathophysiology is still poorly understood. Therefore, using pathophysiological data to detect SCD severity early may be helpful in managing sickle cell anaemia patients.

Zimad-e-Dawālī: Development and Characterization of an Innovative Herbal Cream for Varicose Vein Relief and Management

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Varicose veins, characterized by enlarged and twisted veins, significantly impact health and quality of life, causing discomfort, pain, and aesthetic concerns. Conventional treatments are often invasive or require prolonged medication, highlighting the need for non-invasive alternatives. Unani medicine, with its rich history of herbal remedies, offers promising treatments with minimal side effects. Zimad, a traditional Unani paste made from powdered herbs and oils, has shown potential in treating various ailments but is labor-intensive and inconvenient for patients. This study focuses on reformulating Zimad into a user-friendly cream to enhance its effectiveness in alleviating varicose vein symptoms.

The medicinal herbs used in the preparation of formulation included *Rosa indica, Matricaria chamomilla L* and *Hordeum vulgare.* As per the previous research conducted these are known for their anti-inflammatory, vasoprotective, and analgesic properties. Multiple batches of *Zimad-e-Dawālī* cream were formulated using extracts from the traditional *Zimad* preparation, with minimal additives. The characterization of the formulation was conducted using standard physicochemical tests. These formulations underwent physicochemical evaluations and were compared to commercially available cream.

The optimized cream exhibited physicochemical properties comparable to that of marketed and traditional formulation *Zimad*, effectively preserving the therapeutic benefits of the original formulation's ingredients. It effectively preserved the anti-inflammatory, analgesic and soothing properties of the original herbs, showing comparable performance to existing treatments in terms of skin absorption and therapeutic effect. The study successfully reformulated *Zimad-e-Dawālī* into a user-friendly cream, offering an effective, convenient alternative to the traditional paste. This innovative approach bridges traditional Unani medicine and modern pharmaceutical sciences, providing a non-invasive option for managing varicose veins.

Histopathological Study of Meningeal Haemorrhage in Cases of Head Injury: An Autopsy Study

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Head injury leading to meningeal haemorrhages, including subdural haemorrhage (SDH) and subarachnoid haemorrhage (SAH), is a major cause of morbidity and mortality in traumatic deaths. Determining the cause, mechanism, dating injury is crucial for forensic investigations. Histopathological examination plays a key role in distinguishing between traumatic and non-traumatic causes and in accurately dating the injury, which is essential for medicolegal conclusions. This study aims to evaluate histopathological changes in SDH and SAH cases and correlate them with post-traumatic survival time.

This cross-sectional study was conducted at the Department of Forensic Medicine and Toxicology, AIIMS, Bhopal. A total of 63 medicolegal autopsy cases of head injury with SDH and SAH were examined, excluding decomposed cases and individuals with underlying pathological conditions that could influence haemorrhagic patterns. Collected samples were processed as per protocol. Histopathological findings such as haemorrhage, fibrin deposition, fibroblast proliferation, inflammatory cell infiltration, neovascularization, and cell layer formation were analysed and statistically evaluated using SPSS software.

The shortest post-traumatic survival time recorded was within 1 hour, and the longest was 40 days. In SDH cases, fibrin and neutrophils were observed within 24 hours, while macrophages and inflammatory cells appeared by day 3. Neovascularization and cell layer formation were noted from day 4 onward, becoming more pronounced with longer survival times. In SAH, haemorrhage and neutrophils were present within the first 24 hours, macrophages appeared by day 2, and neovascularization and multiple cell layers were observed from day 4. Histological dating of haemorrhages correlated significantly with post-traumatic survival time.

Histopathological examination serves as a critical tool in forensic investigations, allowing precise dating of meningeal haemorrhages and distinguishing between traumatic and pathological causes. This method enhances the accuracy of medicolegal assessments and aids in reconstructing events leading to head trauma, thereby contributing to justice and public health.

Appraisal of Effectiveness of Holistic Counseling in Management of Type II Diabetes and to Assess Effect of Holistic Counseling on Selected Modifiable Risk Factors Prevailing in Diabetes

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Type II diabetes, is a global epidemic requiring effective prevention strategies, exploring complementary therapies in addition to medications and insulin. The quasi-experimental study aimed to provide holistic counseling to the diabetic subjects and assess the effect of holistic counseling on selected modifiable risk factors of diabetes.

A study on diabetic subjects at a Jiwaji University health centre in Gwalior was conducted focussing on holistic counseling-based intervention. The study included 301 subjects, with a control and intervention group. A validated interview schedule was used to gather demographic data, modifiable risk variables, KAP assessment, simultaneously developing a comprehensive diabetes management counselling module.

The study found no significant difference in demographic profiles among the subjects. One-way ANCOVA revealed that there were lesser ($p \leq 0.05$) manifestation of clinical sign & symptoms and reduction ($p \leq 0.05$) in systolic blood pressure in the intervention group. Appreciable lowering ($p \leq 0.05$) of BMI, waist and hip circumference and subcutaneous fat was noted on counseling in intervention group. Profound impact on ($p \leq 0.05$) in FBG and PPBG and lipid parameters was observed in intervention group as compared to control group. Nutrient intake indicated a significant improvement ($p \leq 0.05$) in intervention group. There was significant ($p \leq 0.05$) improvement in knowledge and practices scores in the intervention group whereas no significant ($p \geq 0.05$) change in the attitude was observed. Counseling intervention exhibited a positive effect on selected modifiable risk factors revealing significant results in subjects with type 2 diabetes. Holistic counseling intervention programs should be implemented frequently to revamp the knowledge and practice of diabetic subjects towards diabetes management.

A Study to Evaluate the Effectiveness of Structured Teaching Programme on Knowledge Regarding Immunization Among Mothers of Under Five Year Children in Selected Community Health Center Gandhi Nagar at Bhopal, MP

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Child development refers to the changes that occur as a child grows and develops in relation to being physically healthy, mentally alert, emotionally sound, socially competent and ready to learn. The first five years of a child's life are fundamentally important. They are the foundation that shapes children's future health, happiness, growth, development and learning achievement at school, in the family and community, and in life in general. To assess the level of knowledge of mothers of under five year children regarding immunization. To evaluate the effectiveness of structured teaching programme on knowledge regarding immunization among mothers of under-five year. To find the association between pre-test knowledge scores with selected demographic variables. A study was conducted to evaluate the effectiveness of structured teaching programme on knowledge regarding immunization among mothers of under five year children.

To aseess the pre existing knowledge of mother regarding data were collected from 30 mothers under five year children Gandhi nagar Bhopal.mp by using self structured questionnaire method score of children regarding immunization among mothers of under-five year was inadequate 21(70%), moderate 7(23%),and adequate2(7%).whereas post-test knowledge score was adequate in 27(90%) mothers, moderate in 3(10%) mothers and none of them had inadequate knowledge after the structured teaching programme.

Finding releted to Distribution of demographic characteristics of the mothers,distribution of sample according to age in year,distribution of sample according educational status distribution of sample according to type of family, distribution of sample source of information, distribution of sample status of mothers.

The Impact of Diet Counseling in Prenatal and Postnatal Phase of GDM and Assessment of Maternal and Neonatal Outcomes

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Gestational diabetes mellitus (GDM) is a significant global health issue that requires attention. Improving glucose metabolism in pregnant women, preventing excessive fetal fat accumulation, and promoting healthy eating habits are crucial to manage GDM effectively.

A controlled carbohydrate diet with low-fat healthy foods can help prevent excessive weight loss and promote better maternal and neonatal outcomes.

The present study was conducted with the aim to study the impact of diet counseling in prenatal and postnatal phase of GDM and assessment of maternal and neonatal outcomes.The study aimed to investigate the impact of dietary therapy on women at high risk of developing Gestational Diabetes Mellitus (GDM).

Researchers recruited 200 women from Gajra Raja Medical College in India, dividing them into two groups: a control group and an intervention group that received dietary and exercise counseling. The study examined the effect of diet counseling on dietary quality, blood glucose control, and maternal and neonatal outcomes, using questionnaires, biochemical analyses, and clinical parameters to assess changes over time**.**

Individualized diet counseling was effective in reducing pregnant women's consumption of unhealthy fats and carbohydrates, and increasing their intake of nutrient-rich foods like green leafy vegetables.

The study found that providing better physical activity counseling helped improved blood glucose levels in the intervention group compared to the control group. The results also showed a lower incidence of complications such as pre-eclampsia, postpartum hemorrhage, and caesarean deliveries in the intervention group. Postpartum blood glucose levels were under control in the counseled group, suggesting that early identification and effective care can reduce these risks for women with gestational diabetes mellitus (GDM).

Expression Profile of Wnt/ ß-Catenin Pathway and Cancer Stem Cell Markers in Head and Neck Squamous Cell Carcinoma: An Immunohistochemical Study

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HNSCC is a major global concern, especially in India, with poor survival & treatment resistance. EMT and CSCs drive tumor heterogeneity, with the Wnt/β-catenin pathway playing a key role in resistance & recurrence. Our study analyzes the IHC expression of Wnt/ ß-catenin signaling pathway markers Slug, ß-catenin, Vimentin & cancer stem cell marker CD44 in HNSCC. Correlate these markers' expressions with the histopathological parameters & TNM staging. Additionally, correlate Slug expression with an aggressive phenotype & poor survival outcome in HNSCC.

A cross-sectional study of 90 HNSCC patients treated at AIIMS Bhopal (2020-2023) recorded clinico-demographical data, tumour morphology, and TNM staging. IHC for Slug, β-catenin, Vimentin, and CD44v6 was performed, with Slug manually stained and others using the VENTANA Benchmark XT. H-scores were calculated, and expression patterns analyzed with statistical tests. Linear regression assessed marker relationships, and survival analysis for Slug was conducted using the Cox model.

The study examined the IHC expression of β-catenin, Vimentin, Slug, and CD44v6 in HNSCC. Cytoplasmic Vimentin, nuclear Slug, and loss of membranous β-catenin were observed, correlating with tumor grade, CD44v6 expression, PNI, LVI, and T-stage. Slug overexpression (HR 2.05, $p = 0.023$) predicted worse survival, highlighting the prognostic value of EMT/CSC markers in aggressive tumor behavior.

Homology Modelling and *In-silico* characterization of Squalene Synthase involved in Bacoside-A biosynthesis in the Ayurvedic plant Brahmi

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Bacopa monnieri, or Brahmi, has been used in Ayurveda medicine, valued for its memory-enhancing properties. Its key bioactive compound, Bacoside-A, exhibits nootropic, antioxidant, and anti-inflammatory effects but is limited by low natural abundance. Understanding the 3D structure of squalene synthase, crucial in bacoside biosynthesis, could optimize production for therapeutic use.

Method- The SQS sequence was retrieved from NCBI in FASTA format and analyzed for physicochemical properties using Expasy's ProtParam tool. Functional and secondary structure predictions were conducted using SOSUI and SOPMA, respectively. The 3D structure was modeled using Swiss-Model and validated for accuracy with PROCHECK and PROVE.

Result and Conclusion- The computed theoretical isoelectric point (pI) was calculated to be above 7, indicating the protein's basic nature. The aliphatic index of 92.22 suggests high thermal stability. The grand average of hydropathy (GRAVY) score of -0.119 implies favorable hydrophilicity, indicating a strong potential for interaction with water. Functional analysis using the SOSUI server identified SQS as a soluble protein. Secondary structure prediction via SOPMA revealed a predominance of alpha helices, complemented by random coils and extended strands. The 3D structure of SQS was modeled using the Swiss-Model server and rigorously validated with PROCHECK and PROVE, confirming the reliability and accuracy of the predicted structure for further research.The successful prediction and validation of the SQS structure provide a reliable model for future studies, laying the foundation for optimizing Bacoside-A biosynthesis and enhancing its production in *B.monnieri*.

Molecular Identification and Characterization of Tomato Leaf Curl Joydebpur Virus and its Associated Betasatellite Molecule with Leaf Curl Disease of *Capsicum annuum* in Madhya Pradesh

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Capsicum annuum (chilli), a member of the *Solanaceae* family, is an economically important crop cultivated worldwide as a spice, vegetable, and medicinal herb. It is a rich source of vitamins A and C known for its counter-irritant properties. However, begomoviruses significantly impact its productivity, causing severe economic losses. This study focuses on the biological, molecular characterisation and diagnosis of *begomovirus* species responsible for severe leaf curl disease on chilli crops in Madhya Pradesh.

Field surveys were conducted in the Bhopal region in November 2024 and found typical begomovirus like symptoms, including upward/downward leaf curl, reduced leaf size, and plant stunting. Symptomatic leaf samples (10) were collected for biological and molecular studies. The causal virus was successfully transmitted by whiteflies (*Bemisia tabaci*) from naturally infected chilli to the healthy chilli and other host plants.

To confirm begomovirus association, total DNA was isolated from symptomatic leaf samples and subjected to PCR using DNA-A, DNA-B and DNA-ß specific primers. DNA-A and DNA-ß were successfully amplified but several attempts failed to amplify DNA-B genome indicating monopartite nature of the begomovirus. The sequence analysis of amplicons revealed the presence of 2761 nucleotides of DNA-A genome (PQ876122, PQ876123, PQ876124) and 1355 nt of DNA-ß molecule (PQ963790). The sequence analysis of DNA-A revealed the highest 90-93% sequence identities and a close relationship with several isolates of *Tomato Leaf Curl Joydebpur Virus* from Bangladesh. The DNA-ß showed the highest 93% sequence identity and closest phylogenetic relationship with *Tomato Leaf Curl Joydebpur Betasatellite.* Based on the highest sequence identities and close phylogenetic relationships of the understudy virus isolate was first time identified as an isolate of Tomato Leaf Curl Joydebpur Virus associated Betasatellite with leaf curl disease of chilli in Madhya Pradesh. This study is useful for the diagnosis and management of *ToLCJoV* in India.

Association of XRCC1 (rs25487, rs1799782) and PARP1 (rs1136410) Polymorphisms and Higher Levels of SOD are Associated with Vitiligo Susceptibility

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Vitiligo is a multifactorial skin disorder characterized by melanocyte destruction, primarily driven by ROS-induced oxidative stress. The BER pathway repairs ROS-induced DNA damage, while SOD neutralizes ROS, potentially reducing oxidative damage. However, the spatiotemporal trigger factors influencing the interplay between SOD activity and BER gene polymorphisms in melanocyte protection remain unclear. This study investigates their combined role in vitiligo susceptibility, focusing on genetic variations, serum SOD levels, and their correlation. Additionally, ongoing enzymatic assays and SOD genetic variation analysis aim to enhance progress in personalized therapeutic approaches.

Clinically diagnosed vitiligo patients (n=180) and healthy controls (n=200) from AIIMS Bhopal were recruited with informed consent. DNA was extracted, and genotyping of *XRCC1* (rs25487, rs1799782), *PARP1* (rs1136410, rs7527192), and *hOGG1* (rs1052133) was performed using PCR-RFLP and ARMS-PCR. Serum SOD levels were quantified via ELISA. A meta-analysis on serum SOD levels (2004–2024) included 873 vitiligo patients and 706 controls from 17 studies. Statistical analysis was performed using the chi-square test and Review Manager (RevMan) Version 5.4. Enzymatic assays are underway to assess correlations between SOD genetic variants and serum SOD levels. This study aligns with progress in personalized medicine approaches to refine predictive biomarkers for vitiligo.

Significant associations were found between vitiligo risk and *XRCC1* (rs25487, rs1799782) and *PARP1* (rs1136410) polymorphisms, while *PARP1* (rs7527192) and *hOGG1* (rs1052133) showed no association. Serum SOD levels were significantly higher in cases (5.637 ± 5.324) than in controls (3.542 ± 3.929). Meta-analysis confirmed increased serum SOD in vitiligo [-0.68 (-1.58 to -0.22), $p < 0.00001$] with high heterogeneity. No significant publication bias was detected. The mean age of onset was 25.90 ± 14.42 years, with 34% showing the Koebner phenomenon. These findings suggest *XRCC1* (rs1799782, rs25487), *PARP1* (rs1136410), and elevated serum SOD levels as potential biomarkers for vitiligo susceptibility. Given the multifactorial origins of vitiligo, integrating genetic and biochemical markers with an understanding of spatiotemporal trigger factors may enhance personalized therapeutic strategies. Ongoing studies will further clarify SOD genetic variations' role in oxidative stress regulation, contributing to precision medicine advancements in vitiligo.

Modulating Cytoskeletal Regulatory Chaperones as a Therapeutic Approach to Mitigate Tauopathy

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Neurodegeneration is associated with the abnormal accumulation of misfolded protein aggregation results in the progressive neuronal loss and neuroinflammation. Tauopathy is a subset of neurodegenerative disease characterized by the abnormal accumulation of microtubule associated protein, Tau in a phosphorylation dependent manner. Under physiological condition, Tau is primarily involved in the stabilization of microtubule. However, under pathological condition (hyperphosphorylation or mutation), the Tau protein detaches from the microtubule resulting in: 1. Self-aggregation of Tau forming neurofibrillary tangles (NFTs) over time, 2. Disruption of microtubule which compromise the neuronal integrity and entangles the NFT within the neurons.

Neurons, being highly vulnerable, require a robust protein homeostasis mechanism mediated by the specialized class of protein known as Chaperones. Our study has identified the specific chaperones as the modifiers of the Tau protein that can serve as target for the therapeutic strategies. To identify molecular modulators of Tau toxicity, we used a genetic screen to identify protein chaperones whose RNAi-mediated knockdown could modulate $hTau^{V337M}$-induced eye-ommatidial degeneration in *Drosophila*. We used the 109 RNAi lines targeting against 64 chaperones. This screen identified the Pfdn5 and Pfdn6 as strong modifiers of $hTau^{V337M}$ cytotoxicity. Further, we generated the loss-of-function of Pfdn5 using CRISPR/Cas9 based genome editing approach to understand the role of Pfdn5 in neurons and Tauopathy.

Consistent with the known function of Pfdn as a cotranslational chaperone for tubulin, *Pfdn5* mutants showed substantially reduced levels of tubulin monomer. However, our study demonstrates the novel function of Pfdn5 in microtubule stabilisation thus, maintain the neuronal integrity. Loss-of-Pfdn5 mimics and synergistically enhances the Tau-induced defects in *Drosophila* further supporting the strong genetic interaction. Proteomics analysis on human Tauopathy patient’s samples revealed that the Pfdn5 expression reduced with age. This suggests that age-dependent decline in Pfdn5 in case of Tauopathy disrupts the microtubule and determine the onset of the neurodegeneration. Consistently, we found that Pfdn5 deletion disrupts microtubule resulting in the formation of Tau protein aggregates. Whereases, overexpression of Pfdn5 stabilises the microtubule and maintain the neuronal integrity thereby, suppressing the Tau-induced progressive neurodegeneration and cognitive decline. Together, these observations suggest that Pfdn5 restrict the Tau-induced progressive neurotoxicity by stabilizing the microtubule and partitioning of Tau on microtubule, thereby maintaining the neuronal integrity.

CRISPR/Cas12a Based Technology for Faster and Specific Detection of Highly Pathogenic Mpox Virus

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Mpox, previously referred as Monkeypox, has currently re-emerged as a highly pathogenic *Orthopoxvirus* infection. The ongoing outbreaks in Africa and several non-endemic countries has transcended this previously obscure pathogen to a Public Health Emergency of International Concern (PHEIC) for the 2nd time after 2022. In the present scenario, minimal vaccination and antiviral strategies warrants the need for highly efficient diagnostic platforms to aid in restricting the spread of Mpox disease.

Polymerase Chain Reaction has long been the gold standard assay for molecular detection of pathogens. Although there is no denying the efficiency and reproducibility of PCR, the need for real-time fluorescence reader or agarose gel electrophoresis makes it expensive and time-consuming. The advent of CRISPR/Cas based diagnostic platforms during the last 5 years has remarkably propelled the development of fast, specific, sensitive and point-of-care testing facilities in resource-limited settings.

Harnessing the precision of guide RNA specific to viral genome, CRISPR/Cas based detection platform boasts of exceptional specificity. In this study, quantitative as well as qualitative analysis is presented demonstrating that incorporation of CRISPR/Cas12a as an endpoint detection assay improves reaction specificity and sensitivity as compared to PCR alone. In addition to fast result interpretation time (< 5 mins), CRISPR/Cas12a based detection is cheaper and requires significantly less amplification cycles to detect even a single copy of Mpox DNA than general PCR. With an abrupt surge in Mpox cases all over the world, it is high time for development of fast and efficient diagnostic strategies. CRISPR/Cas12a based detection, as demonstratedin this study, is a multifaceted tool that takes care of specificity, is ultrasensitive, faster and cheaper while simultaneously providing naked eye result visualization.

Structural Architecture and Amino Acid Composition of Endoproteases: Preventing Auto-Proteolysis by Impeding Cleavage Sites Accessibility Under Physiological Conditions

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Endoproteases hydrolyze internal peptide bonds in proteins, including themselves, necessitating precise regulation to prevent dysregulated proteolysis and auto-proteolysis under physiological conditions. While in vivo mechanisms such as zymogens, inhibitors, and compartmentalization are well-studied, for regulation of their activity. But the resistance of endoproteases to auto-proteolysis under in vitro conditions remains unclear. This study aims to identify the key features that enable endoproteases to maintain their activity and stability while selectively degrading other proteins under physiological conditions. Furthermore, the findings may have broader implications for designing strategies to modulate protease activity in their broad industrial applications.

This study examined six endoproteases, for demonstrating efficient substrate proteolysis while exhibiting minimal auto-proteolysis activity using SDS-PAGE, enzymatic assay, and Gel filtration chromatography method. Notably, lysozyme resisted proteolysis. Our controlled experimental conditions, including stringent reaction termination, likely mitigated false detection of proteolysis, and auto-proteolysis. We also performed detailed structural features and amino acid composition analysis, which plays critical roles in proteolysis susceptibility and auto-proteolysis prevention.

Endoproteases and lysozyme shares higher loop and turn content and a distinctive amino acid profile with higher polar and lower charged residue proportions, contributing to their compactness, reduced solvent accessibility, and structural rigidity. Despite the inherent flexibility of loops, their strategic organization appears to promote global stability. These traits protect cleavage sites accessibility from proteolysis. This study highlights structural architecture and compositional mechanisms underlying endoprotease auto-proteolysis resistance and lysozyme proteolysis prevention, by impeding cleavage sites accessibility to the active site. This analysis offers valuable insights into how these structural characteristics shape proteolytic outcomes, emphasizing the interplay between the primary sequence and the overall protein architecture. Overall, this study provides insights into the finely tuned balance of proteolytic activity and resistance, offering implications for enzyme design for industrial and therapeutic protein drug applications.

Technology Development for Chick Embryo Fibroblast Monolayer-based Cell Culture Rabies Vaccine for Animals

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Rabies is a zoonotic, fatal, and progressive neurological infection. As per WHO, India has become the capital of rabies with over 36 % of the world's deaths. The National Rabies Control Program reported 6644 clinically suspected cases and deaths of rabies between 2012 and 2022.

In India, rabies vaccines are produced using sheep brain (nerve tissue vaccine). However, globally, animal welfare and scientific considerations recommend refining animal procedures, reducing animal numbers, and replacing animal models. Therefore, our objective was to develop a novel rabies vaccine for animals by adapting the Pasteur virus (PV) strain on chick embryo fibroblast monolayer.

Chick embryo fibroblast monolayer was grown and after confluence, the cells were infected with the PV strain of rabies virus. After 24 hrs., cells were trypsinized and virus particles were collected from supernatant by centrifugation. Then, supernatant was used to check infectivity in the mice at different dilutions. After the successful completion of the infectivity assay, viral inactivation was performed by using beta propiolactone followed by adding a stabilizer. Freeze-dried and liquid both were used for validation. Rest all the parameters for vaccine development were followed as per 'Indian Pharmacopoeia'.

A successful development of rabies vaccine from PV strain by using primary cell culture of chick embryo fibroblast monolayer is being done. Further validation of the vaccine was performed on Swiss albino mice. Minimum infectious dose and protective index were calculated, suggesting that the developed vaccine is efficacious as well as safe for use.

A cost effective, more immunogenic, safer rabies vaccine is being developed by using cell culture methodology to bypass the necessity of laboratory animals.

Green Synthesis and Characterization of Copper Oxide Nanoparticles using Ethanol Extract from *Cinnamomum zeylanicum* bark and Their Antimicrobial and Antioxidant Potential

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A cost-effective and environment-friendly technique for green synthesis of copper oxide nanoparticles (CuO-NPs) has been reported. The present study states a green approach for the synthesis of CuO-NPs employing ethanol extract of *Cinnamomum zeylanicum* (CZ) bark (Family-Laureace), commonly known as Dalchini. Ethanol extract of CZ bark was used as a biological reduction agent for synthesizing CuO-NPs by optimizing the synthesis conditions to achieve a narrow size range of nanoparticles. Our primary objective was to comprehensively characterize ethanol extract of CZ bark and CuO-NPs and assess their antioxidant and antimicrobial efficacy.
Structural and compositional characterization of CuO-NPs were done by UV-visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Powder X-ray Diffraction (XRD), Field Emission Scanning Electron Microscope (FESEM), elemental dispersive X-ray analysis (EDX), High-Resolution Transmission Electron Microscopy (HRTEM), Dynamic Light Scattering (DLS), Zeta Potential and Raman spectroscopy. The antioxidant activities of the extracts were measured in terms of hydrogen donating or radical scavenging ability using DPPH. The antibacterial activity of CuO-NPs was assessed against *Enterococcus faecalis*, *Escherichia coli*, and *Candida albicans* through agar well diffusion.

Characterization revealed a distinct absorption peak at 350 nm in UV-visible spectroscopy, spherical morphology under FESEM, and the presence of CuO-NPs in EDX analysis. XRD reveals the monoclinic crystalline morphology of CuO-NPs with an average crystal size 30 nm. FTIR analysis confirms the functional groups of active components present in the extract responsible for the synthesis of CuO-NPs. DLS showed the presence of nanoparticle agglomeration and the zeta potential observed at -29.06 mV. HRTEM revealed nanoparticle dimensions of approximately 20-30 nm. In addition, CuO-NPs demonstrated strong radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) inhibitory activity with an IC_{50} value of 10.89 ± 0.03 μg/mL and showed high antimicrobial activity. Therefore, CuO-NPs could be a feasible alternative source of therapeutic agents in treating bacterial and oxidative stress-induced diseases.

Virtual Screening of Small Molecules for Targeting DYRK1A Kinase: Identifying Novel Inhibitors through Computational Approaches

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Down syndrome (trisomy 21) is the most common genetic cause of neurological disorders. The DYRK1A gene is located in the Down Syndrome Critical Region (DSCR) on human chromosome 21, a region that plays a crucial role in the symptoms of Down syndrome and is mainly responsible for its development.

Here, we screened approximately 75,000 natural product compounds to inhibit DYRK1A kinase enzymatic activity, offering a potential therapeutic approach to alleviate the pathological effects linked to its overexpression in Down syndrome (DS). First, we selected a hundred compounds based on docking scores. After further screening using ADMET properties, we narrowed them to five compounds. The apo system and complexes with the five lead compounds were subjected to 3×200 ns molecular dynamics simulations. Abemaciclib was used as a control molecule, as it has been shown to potentially inhibit DYRK1A enzymatic activity.

Molecular Mechanics Poisson-Boltzmann Surface Area (MM-PBSA) calculations demonstrated that lead1 (ΔG_{bind} = -25.10 kcal/mol) and lead2 (ΔG_{bind} = -22.24 kcal/mol) exhibited higher binding affinities towards DYRK1A kinase compared to the control molecule (ΔG_{bind} = -17.52 kcal/mol). PSN analysis also revealed structural and network changes following ligand binding. Furthermore, using a deep learning approach (DeLA Drug), we identified an abemaciclib analogue exhibiting enhanced binding affinity compared to the control, revealing key interacting residues. Overall, our study provides important insights for developing new and effective DYRK1A inhibitors, with some compounds showing potential as drug candidates, pending confirmation through laboratory testing.

Tyrosine Peptides Alleviates Multifaceted Toxicity Linked to Expanded CGG Repeats in Fragile X-Associated Tremor/Ataxia Syndrome

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Fragile X-associated Tremor/Ataxia Syndrome (FXTAS)/Fragile X-associated Primary Ovarian Insufficiency (FXPOI) are conditions caused by an elevated level of CGG repeats in the 5′untranslated region (5′-UTR) of the Fragile X Mental Retardation 1 (FMR1) gene. These tri-nucleotide extended RNA repeats [r(CGG) exp], produce toxic homo-polymeric proteins in neuronal cells via Repeat-Associated Non-ATG (RAN) translation or formation of RNA foci. A promising therapeutic approach for such conditions involves identifying potent modulators, particularly those with high binding affinity and selectivity towards these expanded RNA repeats.
We investigated the therapeutic potential of homoaromatic tyrosine peptides (2Y, 3Y, and 4Y) towards CGG repeat RNA by employing biophysical and cell model-based studies. Further, administering the peptides from the early developmental stages in the Drosophila model of FXTAS also mitigated the disease symptoms.

Results revealed that the peptides interact with r(CGG) exp in a thermodynamically advantageous manner and are highly selective for the GG-rich RNA motif. All three peptides-correct alternative splicing flaws linked to FXTAS reduce the synthesis and buildup of the FMR1polyG protein inclusion and rapidly suppress cell cytotoxicity in both the cellular and Drosophila models. These findings show that homo aromatics tyrosine-based peptides targeting treacherous repeat RNAs are potential therapeutic tools for treating FXTAS/FXPOI.

Isolation, Characterization and Purification of Type-II Restriction Endonucleases from Soil Samples

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Type II Restriction endonucleases (RE) cleave DNA into fragments at or near specific recognition sites. Soil acts as a major reservoir of microbial genetic diversity. Microbes remain tightly bound to soil, therefore extracting DNA from soil low in clay is easier, and the study of type II RE from such soil is feasible. Based on these facts, the study was designed with the following objectives: Isolation of bacteria from the collected soil samples and preliminary screening of Type- II Restriction enzymes. Selection of Restriction endonuclease positive strains for scale-up from the isolated strains. Purification of the enzyme by column chromatography, and its unit estimation. Identification of bacteria by 16S rDNA amplification and sequencing.

Different soil sources were used to isolate and characterize the presence of RE activity. Colonies were morphologically characterized, and the isolated bacterial colonies were analyzed for Type-II restriction endonuclease activity. The enzyme was purified using column chromatography. PCR was used to amplify the DNA, followed by 16S rDNA sequencing to identify the particular strain of bacteria showing RE activity.

REs are important tools in genetic engineering. Isolated restriction enzymes are used to manipulate DNA in various scientific applications. So we isolated bacterial colonies from the soil to analyze the presence of Type-II restriction endonuclease activity. Due to the high secretion of the alkaline serine protease, *B. licheniformis* is an important bacterium in industrial enzyme production. Subtilisin Carlsberg, secreted by *B. licheniformis* is used as a detergent protease, sold under the name Alcalase by Novozymes. It has been reported that they are found in bird feathers, so scientists are currently exploring its ability to degrade feathers for agricultural purposes. Future research is warranted regarding the characterization of restriction enzyme/s from *Bacillus licheniformis* strain 13 to check the cleavage pattern.

Gut-Brain Axis: *Helicobacter pylori*-mediated Gut Dysbiosis as a Contributing Factor to Neurodegenerative Disorders

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Helicobacter pylori is a pathogenic bacterium causing gastritis and gastric carcinoma. Besides gastric complications, its potential link with gut-brain axis disruption and neurological disorders has also been reported. Our previous study showed that *H. pylori* secretome impact neurological compartment by activating STAT3 and inducing Alzheimer's-related markers. Further, inhibiting pSTAT3 reduced *H. pylori*-induced neuroinflammation and amyloid pathology. Also, as Dysfunction of cellular organelles is crucial to the pathophysiology of neurological disorders and is also linked to the cellular consequences of *H. pylori* infection in the gut. Neurodegenerative diseases progress primarily due to oxidative stress, cellular apoptosis, and neuroinflammation, all of which are exacerbated by disturbances in mitochondrial and peroxisomal dynamics.

To investigate the influence of multidrug-resistant *H. pylori* isolates on neural physiology, AGS cells were infected with HB10, HJ9, and HB1 isolates. Post-infection, the conditioned media were collected, exposed to neuronal and neuronal-astrocytic co-culture systems. This experimental design aimed to examine the impact of *H. pylori*-derived factors on mitochondrial dynamics and their role in neural dysfunction. For the *In vivo* work, Swiss albino male mice were orally gavaged with these three *H. pylori* strains.

Exposure of *H. pylori* secretome promotes mitochondrial fission in neuronal cells by upregulating key fission proteins (Drp1, Fis1, MFF, Mid51) and downregulating the fusion protein MFN1, resulting in reduced mitochondrial membrane potential and mass, likely promoting neuroinflammation. Elevated intracellular Ca^{2+} and decreased calretinin levels suggest excitotoxicity in neurons. In an *In vivo* mouse model, exposure to various *H. pylori* strains resulted in impaired cognitive function and heightened anxiety-like behaviours, as assessed by behavioural assays. The prevailing hypothesis suggests that aggregation-prone proteins and peptides, both endogenous and pathogenic, interact to start a mis regulated aggregation process, which ultimately forms pathological plaques. We evaluated ~230 *H. pylori* secreted proteins for aggregation propensity and identified four proteins and eight peptides with aggregation scores akin to amyloid-beta 42 (Aβ42). These candidates may possess amyloidogenic properties and could serve as biomarkers or therapeutic targets for neurodegenerative disease.

Plant Growth Promoting *Pseudomonas* spp. Significantly Mitigates Drought Effects in Lentil

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Lentil (*Lens culinaris Medik*) plays vital role in Indian food and nutritional security. It is often cultivated in dry and semi-dry regions of the country, where the drought is a primary abiotic factor, resulting in significant yield loss. Plant Growth Promoting Rhizobacteria (PGPR) has been proved as promising solution to mitigate drought effects.

Drought tolerance effects of PGPRs [two *Pseudomonas* strains with five isolates i.e. *P. putida* (D18, IG8) and *P. aeruginosa* (IG24, Zn2, Zn7, Zn9)] were evaluated under different concentrations (5%, 10%, 15%, 20%, 25% and 30%) of Polyethylene glycol (PEG) 6000. All PGPR isolates showed tolerance against water deficit were investigated under both irrigated and drought conditions in three lentil varieties viz. Desi, JL-3 and IPL-316.

PGPRs inoculation significantly improved the plant growth as well as physio-biochemical status of all three lentil varieties Desi, JL-3 and IPL-316 compared to non-inoculated conditions. Among all inoculates, Zn9 exhibited superior growth performance as well as in seed yield (6.02 g/plant) and harvest index (51.11) while IPL316 displayed resilience in days to maturity. Furthermore, Principal component analysis based biplots clearly distinguished the PGPR strains according to their contribution towards drought resilience. By elucidating the impact of PGPR on lentil growth under stress conditions, this research seeks to contribute to the development of strategies for improving crop resilience in the face of increasing environmental challenges.

Molecular Cloning and Development of SCAR Markers for *Chitala chitala* (A Near Threatened Species) for DNA based Rapid Identification

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Chitala chitala (Hamilton, 1822), also known as the Featherback or Clown Knifefish, belongs to the family Notopteridae. It is typically found in rivers but can also adapt to stagnant water; hence, it is also found in ponds and reservoirs. The population of *Chitala chitala* has sadly decreased a lot due to pollution, habitat degradation and fragmentation, water diversions, global climate change impacts, and overexploitation. The major cause of the decline of this species is overexploitation by illegal poaching and catching from natural habitat. Because of this decline, the IUCN considers it as "Near Threatened" (IUCN, 2010). SCAR markers provide valuable insights into the DNA-based rapid identification and relatedness of populations, which is crucial for effective conservation strategies.

During the present investigation, for the development of SCAR markers, two methods were adopted: (i) Direct (by sequencing of unique bands) and (ii) Molecular cloning (by cloning of unique bands and consequently sequencing) and SCAR markers were successfully developed for *Chitala chitala*. Specimens were collected from Halali reservoir and brought to the laboratory for further studies. Genomic DNA extraction, PCR amplification (by 20 random primers), molecular cloning, and sequencing were performed. Initially, both species of the family Notopteridae were morphologically identified by keys provided by scientists. Further, both specimens were also identified by a molecular taxonomy-based technique, i.e., cox1 gene sequencing, and consequently DNA barcoding was developed.

All the collected specimens of both species were morphologically identified. Because of cryptic species of *Notopterus notopterus* and *Chitala chitala*, the morphological data was not sufficient to identified and differentiate these species. Then furthermore, all specimens of both species were identified by sequencing of cox1 gene and successfully identified as *Notopterus notopterus* and *Chitala chitala* of which sequenced genes are available on GenBank database (Accession number: PP594521, PP594522, PP594413, PP594414, PP594415, PP594416 and PP594417). The prime objective of this study is to develop species-specific sequences characterized amplified region (SCAR) markers for proficient and precise identification of closely related species, *Notopterus notopterus* and *Chitala chitala*, which may insure the quality, safety and accuracy of these species. 20 RAPD primers were screened, of which two species-specific RAPD amplicon were selected, gel purified, cloned and sequenced. This sequence, as SCAR marker is available with GenBank. These markers are first reported and will be useful for the identification of closely related species.

Unveiling Airborne Bacterial Diversity: Impacts on Human Health in Rural and Urban Homes

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The air we breathe inside our dwellings serves as an essential link between the built environment and well-being. This study examined the diversity of airborne bacteria in both indoor and outdoor environments of rural and urban dwellings.

We conducted air sampling from traditional and modular kitchens and their open spaces over a one-year period, from December 2022 to November 2023. We collected samples using the settle plate method and performed 16S rRNA metagenomic sequencing for taxonomic identification and functional analysis of the airborne bacterial diversity.

A total of 86 species belonging to 30 phyla, 84 classes, 187 orders, 186 families, and 180 genera were recorded in the indoor and outdoor environments of the rural and urban dwellings. This study revealed a wide diversity of airborne bacteria in both rural and urban dwellings, with several dominant genera identified as, *Acinetobacter*, *Akkermansia*, *Bacillus*, *Bacteroides*, *Brevibacillus*, *Elizabethkingia*, *Haloferax*, *Klebsiella*, *Lactobacillus*, *Paenibacillus*, *Prevotella*, *Pseudomonas*, *Ruminococcus*, *Staphylococcus*, *Succinivibrio*, and *Treponema*. By closely examining at the variety of bacteria in the air, we hope to find links between the microbial profiles and health factors. This will help us understand how indoor microbial communities may affect human health.

Inhibition of Dipeptidyl Peptidase-IV and Antioxidant Properties of Magneto-Primed Soybean Seeds (*Glycine max*): *In Vivo* and *Ex Vivo* Evaluations

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Soybean is a highly valuable crop in the Madhya Pradesh region due to its rich nutritional content, potential health benefits, and high productivity, supported by the favorable climate. Magneto-priming, a promising biophysical technique, has been shown to enhance the biochemical properties of seeds.

In this study, experiments were conducted to assess and compare the effects of a static magnetic field (SMF) on soybean seeds. The seeds were exposed to a 200 mT SMF for 1 hour, followed by a 6-day germination period to isolate bioactive compounds and evaluate their potential as Dipeptidyl Peptidase-IV (DPP-IV) inhibitors. Antioxidant activity was assessed using both the DPPH radical scavenging assay and the Ferric Reducing Antioxidant Power (FRAP) assay, with IC50 values calculated. Additionally, we evaluated the hepatic inhibition activity and hemolysis inhibition of the magneto-primed seeds.

The results demonstrated that magneto-primed soybean seeds exhibited a higher germination rate compared to the control group. Notably, DPP-IV inhibition and antioxidant radical scavenging activities were significantly enhanced in the seeds treated with the static magnetic field, with a 30% increase in antioxidant scavenging activity. These findings suggest that soybean seeds, when magneto-primed, may serve as a natural source of DPP-IV inhibitors, offering a novel therapeutic approach for the treatment of type 2 diabetes mellitus.

Morpho-Molecular Characterization, Diversity Analysis and Antagonistic Activity of *Trichoderma* spp. Isolated from Forest Soils of Central India against *Macrophomina phaseolina*

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Trichoderma species are associated with plants and can be found in soil. These fungi are commonly employed in the production of bioproducts for agricultural systems, as they can control plant diseases directly or indirectly and stimulate plant growth. It protects plants from phytopathogenic infections through various mechanisms, such as secondary metabolism, mycoparasitism, hyperparasitism, enzymes, and induced systemic resistance (ISR). This study aimed to identify 16 *Trichoderma* spp isolated from the forest soil of Madhya Pradesh and Chhattisgarh based on their morpho-molecular characterization, identification of their diversity, and evaluation of the antagonistic activity of these *Trichoderma* isolates against *Macrophomina phaseolina* to find out potential isolate.

The roving survey of the Madhya Pradesh and Chhattisgarh Forest divisions was conducted to collect soil samples. Collected soil samples were screened for the presence of *Trichoderma.* Molecular Identification and diversity analysis of *Trichoderma* isolates were performed through ITS sequencing and the Invitro antagonistic evaluation of these isolates of *Trichoderma* against *Macrophomina phaseolina (Mp)* was performed for the identification of potential isolates by using the confrontation assay described by Morton and Stroube (1995).

Results showed that the sequencing of the ITS region showed that the 16 *Trichoderma* isolates belonged to 10 species: *Trichoderma harzianum, Trichoderma asperellum, Trichoderma erinaceum, Trichoderma rifaii, Trichoderma afroharzianum, Trichoderma koningiopsis, Trichoderma sp., Trichoderma koningiopsis, Trichoderma cf. longibrachiatum, Trichoderma polysporum, and Trichoderma hunua*. Diversity revealed implies that the population has a variety of genotypes, which can be further utilized as a source of bioproducts to offer plants potentially advantageous benefits to help them combat biotic and abiotic challenges and the *in vitro* antagonist activity resulted that *Trichoderma* isolates are fast-growing and showed considerable reduction in the growth of *M. phaseolina*. One of the isolates *Trichoderma hunua* (Isolate number: TD16) showed the maximum inhibition (80.38%) and mycoparasitism against *M. phaseolina*. *T. hunua* is investigated first time for its antagonistic potential and due to its excellent inhibition potential, it can be used as a promising multifunctional bio-fertilizer and bio-stimulant in the future.

Histone Mutations Disrupt Copper Homeostasis Impairing the Sec61-Dependent Protein Translocation Mechanism in *Saccharomyces Cerevisiae*

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Protein translocation from the cytoplasm to the endoplasmic reticulum is an essential step for the maturation of secretory pathway proteins, which occurs through the Sec61 translocon channel. Earlier, we demonstrated that copper toxicity leads to the inhibition of Sec61 channel activity, and histone mutations lead to disruption of copper homeostasis. Thus, understanding the multifactorial regulation of copper homeostasis and Sec61 activity will provide detailed insight into copper metabolism, as their homeostasis disruption contributes to diseased conditions. This study delineates the complex interplay between copper homeostasis and Sec61-mediated protein translocation.

In this study, copper-sensitive yeast histone mutants with impaired *CUP1* expression were used to examine the protein translocation process through immunoblotting. Further, ICP-MS analysis was performed to assess the total copper pool and microscopic imaging of copper-specific fluorescent probes for the determination of the labile copper pool in these histone mutants. We also investigated the role of glutathione and zinc, as well as amino acids like cysteine and histidine, in remediating copper toxicity.

This study unravels a copper-specific impairment of the protein translocation process in the histone mutants. The inhibitory effect of copper on both co-translational and post-translational protein translocations was also demonstrated. We also observed a slight increase in the labile copper pool in the histone mutants. Further, supplementation with a copper-specific chelator, as well as amino acids such as cysteine, histidine, and reduced glutathione, zinc, and the overexpression of *CUP1*, restored the translocation process and promoted growth. This study offers a functional novel insight into the epigenetic and metabolic regulation of copper homeostasis in the Sec61-dependent protein translocation process, which may enhance the understanding of human disorders related to copper metabolism.

Understanding the Mechanisms Underlying TRPV1 Ion Channel Activation

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TRPV1, a polymodal ion channel activated by external stimuli such as thermal, chemical, and pH changes, plays a pivotal role in nociception and sensory signal integration. This study investigates TRPV1 gating mechanisms through TRPV1-TRPV2 chimeras, focusing on the structural and functional contributions of the *N*- and *C*- termini, shedding light on channel regulation and polymodal activity.

TRPV1-TRPV2 chimeras were generated using overlap PCR with rat TRPV1 and TRPV2 genes. TRPV1 cRNA was transcribed, injected into oocytes extracted from adult female Xenopus laevis, and maintained in ND96 buffer. Chimeras were characterized through electrophysiological recordings under a two-electrode voltage clamp, assessing activation by capsaicin, 2-APB, and DkTx in the TRPV1 recording buffer.

This study profiles chimeric channels comprising segments from TRPV1 and TRPV2 to identify gating elements governing structural rearrangements in TRPV1 during ligand-mediated activation. TRPV2, the closest homolog to TRPV1, shares functional and structural similarities, including responsiveness to the TRPV1 agonist 2-APB. Remarkably, TRPV2 variants can be engineered to respond to TRPV1-specific agonists like capsaicin and resiniferatoxin, highlighting shared gating mechanisms. To investigate the role of *N*- and *C*-terminal regions in TRPV1's polymodal activity, the "TMV1" chimera was constructed by incorporating TRPV1's S1–S6 transmembrane helices into a TRPV2 background, leaving only the *N*- and *C*- terminals from TRPV2. TMV1 exhibited a unique "coincidence detection" phenomenon, requiring any two agonists (capsaicin, DkTx, or 2-APB) for activation. Independent replacement of *N*- and *C*-terminals of TRPV1 with TRPV2 counterparts restored single-agonist activation. Sequential swapping identified a six-residue TRPV2 stretch at the *C*-terminal as crucial for coincidence detection in a chimera with a TRPV2 *N*-terminal and the rest from TRPV1. Site-directed mutagenesis in the ankyrin repeat domains (ARDs 3–5) of a chimera with the *N*- terminal of TRPV2 in the background of TRPV1 shifted the channel from single- to dual-agonist responsiveness, highlighting the interplay of *N*- and *C*-terminal regions in TRPV1 gating.

Structural and functional basis for Substrate specificity in M42 aminopeptidase from *E. coli by* small angle X- ray scattering (SAXS)

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Microbial protein metabolism in the gut can significantly affect host health. Members of the *E. coli* are prominent commensals of the human colon. Proteins and peptides that aren't fully digested and reach the colon can be hydrolysed by protease from *E. coli* into amino acids and peptides, which are then subject to further catabolic processes. M42 aminopeptidases are Di nuclear enzymes predominantly present in prokaryotes and entirely absent in eukaryotes. They are suggested to function in the hydrolysis of peptides following the action of the proteasome or similar proteolytic complexes.

This study investigates the structural and functional aspects of the M42 aminopeptidase (M42ec) enzyme, revealing its specific structural features for substrate specificity. We have determined the solution structure of M42ec by Small-angle X- ray scattering (SAXS) at the PX-BL18 INDUS-2 synchrotron. We have determined the oligomeric assembly of M42ec by size exclusion chromatography and dynamic light scattering. We have performed the detailed enzymatic activity of M42ec using various synthetic chromogenic substrates and RP HPLC.

Our findings reveal that the M42 aminopeptidase is a specific enzyme cleaves mainly besides glycine and alanine (with Gly-βNA) and mainly active with cofactor cobalt. Furthermore, our analysis confirms the existence of m42ec as a 12- subunit in the solution. Our enzymatic assays demonstrated that M42ec can cleave various dipeptides and oligopeptides. Given the structural and functional significance of M42 aminopeptidase, our findings hold the critical importance.

Molecular Identification of '*Candidatus* Phytoplasma Species' Associated with Little Leaf Disease of *Ziziphus oenoplia* and *Solanum melongena* from Madhya Pradesh

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Several plant species are being grown in Madhya Pradesh as cereal, oil crops, vegetables and ornamental plants. In India, recent evidence showed that phytoplasma causes diseases in several plant species and results in a serious threat to economically important plants. Phytoplasmas are intracellular obligate prokaryotes which lack cell wall, have small genome and are mainly transmitted by leafhoppers.

Severe little leaf diseases were observed in Oct 2024 on *Ziziphus oenoplia* and *Solanum melongena* with significant disease incidence in Bhopal and Ganjbasoda, Vidisha. Phytoplasma was detected from symptomatic leaf samples by polymerase chain reaction using phytoplasma 16S rRNA gene specific primers. The positive amplicons of the phytoplasma 16S rRNA (1.2 kb) were sequenced and sequence data was GenBank (PQ725601 and PQ725602).

The sequence analysis of 16S rRNA gene of *Z. oenoplia* (PQ725601) revealed the highest 99% sequence identities and a close relationship with several isolates of '*Candidatus* Phytoplasma *balanitae'*. The under study phytoplasma isolate of *S. melongena* also showed highest 96% sequence identities and shared distant phylogenetic relationships with isolates of '*Ca.* P. trifolii' and '*Ca*. P. fraxini' groups. Based on the highest sequence identities and close phylogenetic relationships of *Z. oenoplia* isolate was identified as an isolate of '*Ca.* P. balanitae' (16SrV). The *S. melongena* under study phytoplasma isolate also showed less than 97.55% sequence similarities and distinct phylogenetic relationships were identified as isolates of '*Ca*. P. trifolii' (16SrVI group) and *Ca.* P. fraxini' (16SrVII group). Based on less than 97.55% sequence similarity defined for species demarcation criteria by IRPCM 2004 and distinct phylogenetic relationships isolate under study was considered as a new '*Ca.* Phytoplasma species in *S. melongena*. However the BLL phytoplasma under study was identified as a new '*Ca.* Phytoplasma' species in *S. melongena* in the first time from Madhya Pradesh as well as India.

Optimization of DNA Extraction, PCR Amplification Protocol, and Exploring Cross-Species Transferability through SSR Markers for *Haldina cordifolia* (Roxb.) Ridsdale

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Haldina cordifolia (Roxb.) Ridsdale (Haldu) belonging to the Rubiaceae family is a medicinally important near-threatened tree from Central India.Despite its importance, molecular research on this species, especially using microsatellite or SSR markers is lacking. For molecular research, the quality and integrity of DNA obtained significantly impact the liability of subsequent results. Extracting high-quality DNA from fresh young and mature leaves of Haldu was challenging due to the high presence of plant secondary metabolites, polyphenols,polysaccharides, etc., as with forest trees. In this study, we evaluated five different DNA extraction methods todetermine their efficacy and accuracy.

Among these methods, the newly optimized and modifiedDoyle and Doyle (1987), Tamta et al. (2015), Khanuja et al. (1999), Deshmukh et al. (2007), and charcoal-based Krizman et al. (2006) yielded DNA of sufficient quality in samples of five trees of *Haldina cordifolia*. Notably, after investigation and analysis, the newly optimized and modified Doyle andDoyle (1987) method provided a high DNA yield, while other methods resulted in comparatively lower yields. The genomic DNA yield by this method ranged from 524.7-857.2ng/µl with 1.8 OD (A260/A280) ratio. Molecular investigations are crucial for characterizing, conserving, and implementing effective breeding programs.

Despite the recognized reliability of SSR markers in such research, no molecular marker studies have been conducted on this plant species to date. Cross-species transferability can mitigate the challenge of developing species-specific primers for SSR markers. The cross-species transferability of SSR markers from related species within the Rubiaceae family was successfully assessed in *Haldina cordifolia*, allowing for the investigation of its genetic diversity. This research addresses this knowledge gap by optimizing a high-throughput protocol for DNA extraction and PCR amplification, as well as developing microsatellite SSR markers through a cross-species transferability approach.

Formulation and Evaluation of Cubosomes - based pH Triggered Ocular In-situ Gel Loaded with Miconazole

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The aim of this research is to formulate and evaluate a Cubosomes-based pH-triggered ocular in-situ gel loaded with Miconazole for the treatment of fungal keratitis. Miconazole, an imidazole derivative, is widely used to treat fungal infections but faces challenges related to poor ocular bioavailability and short residence time. The objective is to overcome these challenges by developing a novel ophthalmic formulation that converts from a solution to a gel upon contact with the eye.

Cubosomes were prepared by incorporating miconazole into a mixture of glyceryl mono-oleate (GMO), Poloxamer 407, Carbopol 934, Hydroxypropyl Methylcellulose (HPMC), ethanol, and benzalkonium chloride. The final in-situ gel formulation was obtained by dispersing the Cubosomes in a phosphate buffer at pH 5.5, which triggered gelation upon instillation into the eye.
The formulations were evaluated for various parameters, including drug release, stability, particle size, and zeta potential. The results showed that the cubosome-based formulation significantly improved the local bioavailability of miconazole by extending its residence time in the precorneal area. Furthermore, the gel exhibited sustained drug release and demonstrated good stability and ocular compatibility. This approach enhances patient compliance by offering a prolonged therapeutic effect. The findings suggest that cubosome-based in-situ gels hold promise as effective ocular drug delivery systems for treating fungal infections.

Neuroprotective Efficacy of Quercetin and Orientin with AEDs Against Drug-resistant Epilepsy, Acute Toxicity study and Assessment of Behavioral Comorbidities in Mice

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Epileptic seizure is a widespread neurological condition with multifaceted physiology. Numerous scientific data advise the therapeutic efficacy of bioflavonoids or bioactive compounds in epilepsy against the oxidative stress pathway. Thus, the main objective of this investigation has undertaken to explore the neuroprotective efficacy and Comparative study of Quercetin (Que) and Orientin (Ore) bioflavonoid with selected anti-epileptic drugs (AEDs) against drug-resistant model such as, Pentylenetetrazole (PTZ) induced kindled model of convulsions in mice.

Swiss albino mice (20-30 g) were individually separated into nine groups (n = 6). Before PTZ administration, Que and orientin were dissolved in 0.6% w/v CMC sodium and served for 7 days orally. On the seventh day, 30 minutes before PTZ administration, Lamotrigine (Lmt) and Gabapentin (Gbp) were solubilized with saline and given as single i.p. injections. PTZ (30 mg/kg, i.p.) was given in a sub-convulsive dose on alternate days for 12 days until the mice seemed to have complete motor seizures.

PTZ dosage in the sub-convulsive range (30 mg/kg, i.p., alternative day for 12 days) resulting in a progressively rise in convulsive behavior (seizure score). Que (20 mg/kg, i.p.) + Lmt (15 mg/kg, i.p.) administration for 12 days exhibited improvement in transfer latencies. In a histopathological study, microphotographs (40×) of the brain tissue of mice showed cell morphology in the different experimental treated groups. PTZ caused considerable oxidative stress, as evidenced by elevated nitrite and lipid peroxidation, as well as reduced levels of glutathione and catalase enzymes. This investigational research illustrates the participation of the nitric-oxide biomechanism in the promising therapeutic outcomes of Lmt with Que and Ore as an adjuvant drug, which can provide hope that Que might be involved as a complement drug with Lmt in medicinal therapies of generalized epileptic patients and interrelated issues.

Design, Optimization and *In Vivo* Evaluation of Tazarotene Loaded Emulgel Formulation for the Treatment of Acne

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The emulgel delivery system is a novel and innovative drug delivery platform that combines the advantages of both emulsions and gels, offering dual control over drug release and enhanced stability for topical applications. Tazarotene (TZR), an anti-acne drug with low water solubility, poses challenges for effective topical delivery. This research aimed to develop, optimize, and characterize a tazarotene-loaded emulgel formulation to improve its therapeutic efficacy.

Emulgels were prepared using the incorporation method and optimized through a Box–Behnken statistical design (BBD). Three independent variables—concentration of carbopol 940 (X1), span 80 (X2), and tween 80 (X3)—were evaluated for their effects on percentage drug release (Y1) and viscosity (Y2). The optimized formulation was characterized for parameters such as pH, viscosity, spreadability, extrudability, and drug content. *In vitro* drug release studies were performed over 7 hours, and a skin irritation study using mice was conducted to assess safety. Anti-acne activity was evaluated in a murine model of acne induced by *Propionibacterium acnes* inoculation, comparing the optimized emulgel with a marketed gel.

The optimized tazarotene-loaded emulgel exhibited acceptable physicochemical properties, including pH (6.6 ± 0.3), viscosity (28945 cPs), spreadability (6.17 ± 0.02 cm^2), extrudability (18 ± 2.49 g/cm^2), and drug content (85.46 ± 4.02%). *In vitro* drug release studies revealed a high percentage of drug release (87.59 ± 2.6%) at 7 hours. Skin irritation studies indicated that the formulation was safe, with no erythema or edema observed in mice after 24 hours. The anti-acne activity study demonstrated that the optimized emulgel effectively reduced acne diameter to 0 mm from 4.5 mm, outperforming the marketed gel, which reduced the diameter to 1.20 mm from 4.60 mm. These results suggest that the tazarotene-loaded emulgel is a promising system for topical acne treatment.

An Approach to Enhance the Efficiency of Endoxifen as Anticancer Agent by Conjugating with Anticancer Short Peptides

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Globally, women are concerned about their health due to breast cancer. Researchers are focusing on enhancing the quality of life for breast cancer patients, as of right now, there isn't a single treatment that can be used to cure breast cancer permanently. This research aims to enhance the effectiveness of endoxifen (tamoxifen derivative) through conjugation with anticancer tripeptides. It was also ascertained through molecular docking studies using auto dock software.

This study presents the synthesis and characterization of tripeptides produced via manual solid-phase peptide synthesis. The synthesized tripeptides were analysed using mass spectrometry, NMR spectroscopy, and differential scanning calorimetry (DSC), with progress being monitored by reverse-phase thin-layer chromatography (TLC). These tripeptides were subsequently conjugated with endoxifen, and the resulting conjugates were characterized using mass spectrometry and NMR spectroscopy. Finally, the synthesized tripeptides and their conjugates will undergo *in-vitro* screening to assess their anticancer activity."

The tripeptides were successfully synthesized using manual solid-phase peptide synthesis, with progress monitored by TLC. Mass spectrometry and NMR spectroscopy were used to characterize their structure, while DSC demonstrated their thermal stability. The tripeptides were conjugated with endoxifen and characterized by mass spectrometry and NMR spectroscopy. The conjugates showed good stability under experimental conditions. Both the tripeptides and their conjugates will be evaluated for anticancer activity. The conjugates are expected to exhibit significantly greater cytotoxicity than the tripeptides alone, likely due to synergistic effects enhancing cellular uptake or target specificity.

Machine Learning-Driven Insights into Nanoparticle Delivery Efficiency and Phytochemical Synergy for Targeting TNBC Resistance

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Nanoparticle-based drug delivery systems have revolutionized cancer therapy, offering enhanced targeting and reduced systemic toxicity. However, the unpredictable in vivo behavior of nanoparticles and the emergence of drug resistance, particularly in triple-negative breast cancer (TNBC), remain critical challenges. Factors such as nanoparticle size, shape, material, surface modifications, targeting strategies, and tumor microenvironment dynamics significantly influence delivery efficiency. Additionally, understanding molecular crosstalk between key oncogenic pathways is essential to designing synergistic therapeutic strategies for overcoming resistance.

A dataset of 533 entries was analyzed to assess the physicochemical properties of nanoparticles and their delivery efficiencies in preclinical cancer models. Machine learning techniques, including Ridge Regression, ElasticNet, Gradient Boosting, and Random Forest, were employed to identify critical determinants of delivery efficiency. Feature engineering, robust cross-validation, and independent dataset evaluations ensured model accuracy and interpretability. Furthermore, molecular docking studies using NPACT, NPASS, and NPAtlas databases were conducted on Cyclin D1, Notch receptors (1-4), BRCA, STAT3, EGFR, and c-Met to investigate their crosstalk and identify phytochemical agents with potential synergistic activity. These phytochemicals were evaluated for their ability to overcome drug resistance and enhance the efficacy of erlotinib-loaded, surface-modified nanoparticles.

Ridge Regression achieved strong predictive accuracy (MSE = 1.87, $R^2 = 0.95$), with ElasticNet and Huber Regressor showing comparable performance ($R^2 = 0.96$). Ensemble models, including Gradient Boosting and Random Forest, demonstrated excellent prediction capabilities ($R^2 > 0.87$) for 24-hour delivery efficiency. Molecular docking identified key phytochemicals capable of targeting multiple oncogenic pathways and enhancing TNBC treatment by modulating resistance mechanisms. These findings provide insights into rational nanocarrier design and the integration of phytochemical synergy for optimizing TNBC therapy.

Future work will explore the transition from traditional machine learning models to advanced deep learning frameworks to further enhance predictive accuracy and interpretability of nanoparticle delivery efficiency. Additionally, the top-performing docking results will undergo molecular dynamics simulations to evaluate binding stability and elucidate the mechanisms underlying their synergistic effects.

Investigating Mechanism of Action of Lasioglossin-III and its Recombinant Variants Through MD Simulation Studies

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To explore the molecular mechanisms of Lasioglossin-III (LL-III) and its recombinant variants during interactions with bacterial and mammalian membranes using molecular dynamics simulations. The study evaluates the impact of N-terminal methionine addition and C-terminal amidation on membrane specificity, antimicrobial efficacy, and biocompatibility, supported by experimental assays. Lasioglossin-III (LL-III) is a potent antimicrobial peptide with specificity for bacterial membranes due to its optimized charge and hydrophobicity. However, recombinant production of the same can alter its structure, affecting its function. Hence Combining coarse-grained and all-atom simulations with in vitro tests, this study provides insights into LL-III and its recombinant versions' membrane interactions as a potential solution for combating drug-resistant bacteria.

The peptide structures were modeled using AlphaFold2 and simulated with GROMACS. Coarse-grained molecular dynamics simulations were performed for 500 ns using the Martini force field to study membrane interactions, followed by conversion to all-atom (AA) models for detailed analysis using the CHARMM-GUI interface. Antimicrobial activity was assessed using diffusion assays against *E. coli* and *S. aureus*. Hemolysis was evaluated using human red blood cells, and Data were analyzed using VMD and Discovery Studio.

Lasioglossin-III (LL-III) and its variants demonstrate high specificity for bacterial membranes, attributed to electrostatic and hydrophobic interactions, with minimal mammalian membrane affinity. Structural modifications, such as N-terminal methionine addition (P2) and C-terminal amidation (P1), significantly influence binding and antimicrobial activity. P1 showed stable interactions with Gram-positive and Gram-negative membranes, while P2 displayed faster binding and enhanced membrane disruption. All variants exhibited minimal hemolysis, with P3 being the least hemolytic. Electrostatic interactions facilitate initial binding to bacterial membranes, with hydrophobic forces stabilizing attachment. LL-III’s optimized charge-hydrophobicity balance ensures potent and selective antibacterial activity, influenced by structural modifications. This study emphasizes LL-III's potential as an antimicrobial agent and offers insights for developing peptide-based therapies against drug-resistant bacteria.

Preparation and Characterization of Amino Acid Functionalized Nanocellulose for Peptide Delivery

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Preparation and Characterization of Functionalized nanocellulose for peptide delivery. In recent years, nanocrystalline cellulose (CNCs), a term referring to cellulose based nano- material, has generated considerable interest due to its excellence physicochemical properties and the wide of potential applications in many fields. Nanocellulose has tremendous importances for biomedical applications because of its remarkable features including recyclability, biocompatibility, tunable surface area and low risk of toxicity.

Basically, the amorphous regions of cellulose could be removed after chemical or physical treatment, leading to the formation of cellulose nanoparticles with highly arranged crystalline regions. The production of nanocellulose by the acid hydrolysis and TEMPO mediate treatment of cellulose which derived from the natural resources. Preparation of Oxidized Nanocellulose Suspension and Coupling of ONC with amino acid and Trp based peptide (Trp-Pep).

Nanocellulose characterized by the electronic microscopy, X-ray diffraction, infrared spectroscopy, particlesize distribution and NMR. The release time of nanocellulose-based system varies from a fewminutes to several days as they provide a controlled and sustained release property. These system showed emerging potential for developing controlled drug delivery for different route of administration (oral, transdermal). Present study will facilitates the selection of proper source and processing techniques for nanocellulose production and provide different opportunities in ongoing research into its application in drug delivery.

Synthesis, Characterization, and Biological Evaluation of Kojic Acid and Isatin Derivative: In Vitro Anticancer and Antioxidant Activity

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Kojic acid, a natural compound with notable biological properties, serves as a versatile scaffold for developing novel therapeutic agents. This study aimed to synthesize Kojic acid-based derivatives and evaluate their dual functionality as anticancer and antioxidant agents. The exploration of these derivatives holds promise for advancing cancer therapeutics and managing oxidative stress, addressing the pressing need for multifunctional compounds in modern medicine.

Kojic acid derivatives were synthesized through one-pot chemical reactions and structurally confirmed using advanced spectroscopic techniques, including FTIR, NMR, and mass spectrometry. Its anticancer potential was evaluated in vitro using the MTT assay against human cancer cell lines: HCT-116 (colon cancer), PANC-1 (pancreatic cancer), MDA-MB-231 (triple-negative breast cancer), and MCF-7 (hormone-responsive breast cancer). Antioxidant activity was assessed using the DPPH assay to determine radical scavenging properties.

The synthesized Kojic acid-Isatin derivative (KAI) exhibited dose-dependent cytotoxicity, demonstrating anticancer activity at higher concentrations (>50 µM) across all tested cell lines. Additionally, KAI displayed moderate radical scavenging activity in the IC_{50} 2.01 against standard ascorbic acid IC_{50} -2.79 at 20µg/mL antioxidant assay, suggesting the moderate potential to mitigate oxidative stress. These findings highlight that the KAI could be a candidate for therapeutic applications. Further structural optimization is acceptable to enhance their potency and selectivity, reinforcing their value in the fight against cancer and oxidative stress-related disorders.

Carotenoid-loaded nanogel for effective management of skin cancer

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Skin cancer is a growing health concern with increasing prevalence and mortality rates worldwide. While treatment options exist, they remain limited against aggressive and metastatic cancers. Naturally occurring compounds like carotenoid have demonstrated promising anticancer potential; however, their clinical translation remains suboptimal due to poor solubility, instability, and bioavailability. The current study aimed to isolate carotenoid from the seeds ethanolic extract of *Nyctanthes arbortristis* Linn to develop carotenoid-loaded nanogel to enhance its delivery topically to skin tissues for potential treatment benefits. Biocompatible chitosan nano gels were synthesized to encapsulate lipophilic carotenoid using an ionic gelation method optimized by Box-Behnken design. The size of the vesicles for the formulations was between 202±14.2 nm-374±127 nm, while the entrapment efficiency was between 61.22±0.23% - 85.16±0.24%, and the drug release % after 8 h was between 48±0.82%- 76±0.52%. *In vitro* studies demonstrated the potential of the nanogel in significantly inhibiting the proliferation of skin cancer cells, evidenced by its cytotoxic effects on A375 and B16F10 cell lines while exhibiting minimal impact on healthy skin cells. Additionally, *Ex vivo* studies of the nanogel showcased efficient penetration into deeper skin layers, promising enhanced drug delivery to the tumor site. Furthermore, animal studies conducted on DMBA-induced skin cancer animal models corroborated the therapeutic efficacy of the carotenoid-loaded nanogel, revealing marked suppression of tumor growth compared to conventional treatment by marketed gel or untreated groups. These findings supported the potential of this carotenoid nanogel formulation as a promising strategy for skin cancer therapy, offering targeted delivery, reduced systemic toxicity, and improved treatment outcomes. Further preclinical development of this targeted delivery system can facilitate clinical advancement of this natural bioactive as a therapeutic modality for topical skin cancer treatment.

Evaluation of Phytochemicals and Antiurolithiatic Properties of Aqueous Momordica Charantia Fruit extract in an Ethylene Glycol-Induced Urolithiasis Model

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In traditional medicine, the fruits of *Momordica charantia* Linn. (Family: Cucurbitaceae) have been used for the treatment of urinary stones. However, scientific evidence supporting its nephroprotective and antiurolithiatic properties remains limited. This study aimed to evaluate the qualitative phytochemical composition and antiurolithiatic activity of an aqueous extract of *M. charantia* fruits collected from the Sagar region of Madhya Pradesh.

Phytochemical analysis was conducted using established protocols to identify key constituents. Urolithiasis was induced in rats (Groups II–V) by administering 0.75% ethylene glycol in drinking water for 28 days, except for the normal control group (Group I). The study included five groups:

- **Group I**: Normal control
- **Group II**: Negative control (hyperurolithiatic)
- **Group III**: Standard treatment (Allopurinol, 120 mg/kg)
- **Groups IV & V**: Treatment groups receiving *M. charantia* fruit extract (100 mg/kg and 200 mg/kg, respectively)

Biochemical parameters related to urolithiasis were assessed in urine and serum samples. Phytochemical screening confirmed the presence of carbohydrates, alkaloids, saponins, and flavonoids. Treatment with *M. charantia* fruit extract (100 mg/kg and 200 mg/kg, p.o.) significantly reduced ($P < 0.001$) elevated levels of serum creatinine, urine protein, and urine calcium, while significantly increasing ($P < 0.001$) urine output, urine creatinine, and serum calcium levels. These effects were comparable to those observed in the standard treatment group. The findings suggest that *M. charantia* fruit extract effectively reduces and prevents urinary stone formation, supporting its traditional use in managing urolithiasis. The observed reduction in stone-forming constituents in urine and renal tissue indicates its potential as a natural antiurolithiatic agent. Further studies, including clinical trials, are warranted to validate its therapeutic benefits.

Synthesis and Wound Healing Evaluation of Heteroaromatic derivatives of Gallic Acid

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Wound healing is a complicated process, and the effective management of wounds is a major challenge. Owing to the antioxidant property of GA and the study of structural features it was hypothesized to design new small molecule wound healing drugs based on GA containing piperazine/piperidine. The objective of the present work was to design and synthesize newer gallic acid derivatives that would be able to heal wound.

The two step reaction involved the formation of acid chloride of GA and its conversion to the target compounds in presence of acetone. All the compounds were subjected to evaluation of wound healing effect using the widely used excision wound model in wistar rats. Topical therapy was applied twice a day using 1%, 2%, and 3% w/w piperazine/piperidine containing ointment, and the measurement of the wounds area was carried out every 3 days, after that the wound closure percentage was calculated in 7 & 14 days along with histological examinations.

The objective of the present work was to design and synthesize newer gallic acid derivatives that would be able to treat wound healing activity. In the present work the target compounds were synthesized in two steps. The structure elucidation of the compounds was performed by IR, 1HNMR and mass spectroscopy.

Wound healing activity evaluation of piperazine/piperidine containing ointment showed the significant increase ($p < 0.05$) in the wound closure percentages in rats treated with piperazine/piperidine containing ointment 1% and 2% comparing to those of non-treatment group ,wound tissue samples on day 7 and 14 demonstrated higher accumulation of collagen fibers, reduction of edema and inflammation and also formation of tissue appendages in 1% and 2% piperazine/piperidine containing ointment treated groups.

The results led to the conclusion that gallic acid conjugated to piperazine or piperidine could be a potential lead for designing of novel wound healing molecules.

Applying Green Analytical Chemistry Principles for Simultaneous Estimation of Metformin HCl and Pioglitazone by UV Spectrophotometry

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Simple, Rapid, sensitive, robust, and validated UV-spectrophotometry was developed to quantify antidiabetic drugs Metformin HCl (MFH) and Pioglitazone (PIO) in bulk and formulation. The paper outlines a UV spectrophotometry method for analyzing metformin HCl and pioglitazone, following Green Analytical Chemistry principles. Major pharmaceutical companies and research laboratories use green analytical methodologies to develop environmentally benign analytical methods.

The present work is based on the principle of iso-absorptive point to the determination of two components simultaneously. Diluent for dissolving the metformin HCl and Pioglitazone was used 0.07 M Formic acid (pH 2.4): Ethanol 57:43 (v/v) and further dissolving medium was used 0.03 M KH_2PO_4 buffer (pH 5.6): Ethanol 59:41 (v/v).

The linear range was established between 1-9 µg/mL for metformin HCl and 2-18 µg/mL for Pioglitazone. Metformin HCl and Pioglitazone were found to have DLs of 0.2652 µg/mL and 0.6171 µg/mL, respectively. Metformin HCl and Pioglitazone were found to have QLs of 0.8037 µg/mL and 1.8700 µg/mL, respectively, and with a mean recovery percentage of 99.89 ± 1.74% for Metformin HCl and 100.18 ± 1.44% for Pioglitazone. The environmental sustainability of the developed UV spectrophotometric approach was evaluated using the Analytical Eco-scale, AGREE, and GAPI metrics, demonstrating the method's eco-friendliness in solvents, chemicals, energy consumption, and waste generation. The proposed method, characterized by its simplicity, cost-effectiveness, and environmental sustainability, may serve as a viable alternative to hazardous chemicals in the routine analysis of the chosen dual medicine combination.

Repurposing of Anti-Inflammatory Drugs of Trimethyltin Induced Neurodegeneration

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Inflammation is the most important function that regulates cellular homeostasis through regeneration and degeneration processes. But excessive and long-term-induced inflammation causes the release of inflammatory mediators that lead to an increase in the form of neuroinflammation that causes the emerging neurodegeneration process. Currently, some market drugs are available to inhibit the neurodegeneration process, but they have more adverse effects. Now clinical research is focusing on the treatment of complex inflammatory phenomena that are associated with neurodegeneration. In these studies, the non-steroidal anti-inflammatory drugs Etoricoxib and Mefenamic acid (5 mg/kg body weight) were selected based on the reduced neuroinflammation and neurodegeneration effect of Trimethyltin (0.0625 g/kg body weight) in normal female Swiss Albino mice. The mice were randomly divided into following four groups: Control group, treatment group, diseased induced group. The study found that non-steroidal anti-inflammatory drugs reduce the neurodegenerative effects of trimethyltin, which has been known on the basis of reducing the concentration of biochemical parameters and memory-based behavioural analysis. In this study, parameters showing beneficial effects, both the NSAIDS drug Etoricoxib and Mefenamic acid regulate the inflammation pathway on neurodegeneration.

Nanofiber-Assisted Stabilization of Cationic Ethosomes for Enhanced Skin Penetration of Bleomycin Sulphate in the Treatment of Skin Cancer

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Skin cancer remains a significant global health issue, with its frequency steadily increasing in recent years. Conventional treatments like surgery, chemotherapy, and radiation have limitations, but topical chemotherapy offers promise by reducing systemic toxicity. However, Bleomycin Sulphate (BLM) faces challenges in penetrating the skin effectively. Cationic ethosomes, known for their ability to penetrate skin well, address this by enhancing interactions with cancer cells. Ensuring stability of drug delivery systems is crucial. Nanofibers, known for stability and large surface area, provide a base for cationic ethosomes, allowing localized delivery and improved stability.

Using thin film hydration, BLM-loaded cationic ethosomes were prepared and incorporated into nanofibers using electrospinning. Characterization involved surface morphology and drug release kinetics. *Ex-vivo* skin permeation and *in-vitro* studies in A431 cell lines were conducted, along with *in-vivo* anticancer activity assays.

The findings indicate that the optimized BLM ethosomes formulation exhibits an entrapment efficiency of 27.1% and a vesicle size of 144 nm, displaying a smooth surface morphology and a positive zeta potential. The optimized ethosome (BLM-ETH) was then integrated into nanofibers using the electrospinning method with various polymer ratios. Physicochemical properties of the formulations BLM-ETH and BLM-ETH-NF4, including drug entrapment, loading, particle size, surface charge, morphology, and in vitro drug release, were evaluated. Both formulations demonstrated approximately 82% and 50% in vitro drug release after 96 hours, respectively, following Higuchi and Korsmeyer-Peppas models. Ex-vivo evaluation on Swiss albino mice skin demonstrated the formulations' impressive penetration ability and retention within skin layers. The results suggest that BLM ethosomes hold promise as a drug delivery system for targeted topical delivery at cancer sites. While *ex-vivo* studies highlight enhanced permeation efficacy, further *in-vitro* and *in-vivo* antitumor studies are crucial for comprehensive therapeutic assessment.

Investigating the Involvement of Adenosine Monophosphate-activated Protein Kinase (AMPK) Activator in Chronic Unpredictable Stress-induced Diabetes Mellitus in albino Wistar Rats

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The function of 5′-adenosine monophosphate-activated protein kinase (AMPK) in the management of chronic illnesses, medical nutrition, and obesity, as well as its connection to nutrition, will be discussed in this study. There are very few studies in the literature that look directly at the connection between AMPK and nutrition. This is why all the research that can be found by searching for AMPK and disease, AMPK and health, AMPK and exercise, and AMPK and diet has been combined into a single document. In many pathological circumstances, including inflammation, diabetes, aging, and cancer, AMPK is suppressed. Conversely, AMPK activation has beneficial benefits in a variety of disorders, including insulin resistance, diabetes, obesity, cancer, and Alzheimer's. Examining the connection between AMPK and nutrition, it. In many pathological circumstances, including inflammation, diabetes, aging, and cancer, AMPK is suppressed. Conversely, AMPK activation has beneficial benefits in a variety of disorders, including insulin resistance, diabetes, obesity, cancer, and Alzheimer's. AMPK is inhibited by food intake, although diets that are particularly high in fat and carbohydrates are more effective at this stage, according to research on the interaction between nutrition and AMPK. Furthermore, it appears that AMPK is inactivated by high fructose corn syrup and long-chain saturated fatty acids, which are elevated by industrial food consumption and frequent meals. Taking into consideration the human circadian rhythm, techniques like evening fasting and intermittent fasting are advised for AMPK activation in medical nutrition therapy.

Exhaustive Computational Analysis of Pyrimidine Derivatives as GPR119 Agonists for the Treatment of Type 2 Diabetes Mellitus

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Type-2 Diabetes (T2DM) is a long-term medical disorder characterized by Insulin deficiency and high blood glucose levels. Among other medication to cure T2DM, the review of the literature found that various Pyrimidine derivative act as an agonist for G-protein-coupled receptor 119 (GPR119) was proposed to control blood glucose levels by enhancing the function of pancreatic beta-cells and its mechanism of action with fewer adverse effects. In the present research work, in-silico investigations were carried out to investigate the potential of Pyrimidine analogue as an agonist to the protein target GPR119 receptor. We performed exhaustive molecular modelling and protein modelling methodologies such as homology modelling, molecular docking along with various drug designing tools such as 3D-QSAR and pharmacophore mapping to ascertain the design of better GPR119 agonists.

On the basis of in-depth computational studies, we designed new pyrimidine moiety and analyzed them for GPR-119 receptor agonist and further explored the ADME properties. Designed compounds found to exhibit better predicted activities as compared to reference compound; The current research on pyrimidine derivatives, using molecular docking, 3D-QSAR and Pharmacophore mapping demonstrated that the obtained computational model has significant properties and the designed molecules and Dataset from this model, produced antidiabetic compound against the target GPR119 i.e., compound 1S, 1Z and 1D with the docking score of −11.696, -9.314 and -8.721 respectively. The pharmacokinetics and drug-likeness studies revealed that these compounds may be the future candidate for the treatment of diabetes acting via GPR119 agonist mechanism.

Isolation and Characterization of Therapeutically Active Phytoconstituents from *Catunaregam Spinosa* (Thunb.) and *Tecoma Stans* (L.)

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Background: In this study, 6 compounds were isolated from two medicinally important plants- *Catunaregam spinosa* (Thunb.) and *Tecoma stans* (Linn.). The plants have been described in Ayurveda and are traditionally used by local people for the treatment of various diseases. Literature survey reveals that the above stated plant contains phytoconstituents having different pharmacological activities. The study aims at achieving following goals:

- Isolation active constituents from crude extracts and identify the chemical structures of isolated compounds.
- Ascertaining the pharmacological activity of the extracts and isolated compounds in treating cardiovascular diseases through in vitro and in vivo studies.
- Integration of AI and molecular modelling techniques to screen bioactive compounds, predict interactions with cardiovascular targets, and validate their therapeutic potential.

Materials and methods: for extraction- distillation, Soxhlet extraction, isolation of the constituents of plant extracts were done using column chromatography and then further characterization of isolate was done by Infrared Spectroscopy and Nuclear Magnetic Resonance (^{1}H-NMR) and Mass spectroscopy.

Result and Discussion: 3 compounds were isolated from each plant. An alkaloid, 'Tecomine' from leaves, a phenyl propanoid glycoside, 'Crenatoside' from trunk of the plant and a glucoside, 'Plantarenaloside' were isolated from root of the plant *T. stans*. From *Catunaregam spinosa*, 'β sitosterol' from leaves, a glucoside, '11-methylixoside' from stem bark and a triterpenoid '1-keto-3α-hydroxy oleanane' from root of the plant were isolated. The structures of the compounds were validated from IR, UV, MASS and ^{1}HNMR spectroscopy. These isolated compounds have the potential in treatment of cardiovascular diseases as the phytoconstituent polyphenols have antioxidant properties, sitosterol decreases blood cholesterol levels, glycosides are already known to treat irregular heartbeats and heart failure.

Targeted Delivery of Doxorubicin to Breast Cancer Cells Using CPP-Conjugated Liposomes

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Cancer remains one of the leading causes of mortality worldwide. The present study focuses on the design and formulation of DOX-loaded pegylated liposomal systems (LD) modified with $(CR)_4$ peptide (LDM) to enhance tumor-targeting efficiency while minimizing systemic side effects.

LD and LDM were prepared using the remote loading technique and optimized via the Box-Behnken design (BBD) within the Response Surface Methodology (RSM). Characterization studies confirmed the spherical morphology, size, charge, and drug entrapment efficiency. Functional assessments included in vitro release, cytotoxicity, hemocompatibility, and in vivo biodistribution.

LDM exhibited a vesicle size of 118.5 ± 1.28 nm, PDI 0.291 ± 0.006, zeta potential 12.35 ± 0.91 mV, and 67.344 ± 1.27% drug entrapment efficiency. *In vitro* drug release at pH 6.8 showed sustained release (66.66 ± 1.98% over 72 hours). The SRB assay demonstrated superior cytotoxicity of LDM, with an IC_{50} of 4.9 ± 0.91 µM against MCF-7 cells. Additionally, LDM caused enhanced nuclear fragmentation, ROS generation, and mitochondrial membrane potential disruption. Hemolysis studies revealed significantly reduced hemolysis (4.23 ± 0.17%) for LDM compared to free drug (44.5 ± 0.23%), with no effect on coagulation pathways. *In vivo* studies indicated sustained release, high tumor retention, and reduced organ toxicity, confirming LDM's safety and efficacy. Overall, LDM presents a promising targeted delivery system for breast cancer therapy, exhibiting potent antitumor effects with excellent biocompatibility.

Virtual Screening of Compound Library Against Dpre1: Molecular Docking Approach for Tuberculosis Drug Discovery

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According to estimates from the World Health Organization, TB affects about one-third of the world's population, making it a serious global problem. Emergence of drug-resistant (DR) and extensively drug-resistant (XDR) strains of TB has underscored the pressing need for innovative therapeutics. In this study, we present the outcomes of virtual screening involving 4500 compounds targeting a pivotal drug receptor, DprE1, an enzyme involved in cell wall biosynthesis.

The virtual compounds employed in this study were sourced from the Molmall database, which selected diverse datasets with distinct pharmacophores and was subsequently screened through molecular docking using AutoDock-Vina. Following the virtual screening, compounds were filtered using binding affinity, Lipinski's Ro5 calculation, PAINS Filters & ADMET Evaluation. Molecular Dynamics studies were carried out for 200 ns on the *Mtb* DprE1 protein complexed with the top lead dock scorer compounds.

Out of 4500 ligands, 115 hits with higher binding energy than the reference ligand were found through a virtual screening process. Following screening using PAINS and Lipinski's Rule of Five, 39 candidates were identified as possible oral medications. The ADMET Lab 2.0 *in silico* ADMET study produced a shortlist of four hits (Ligand 1243, 1267, 3813, and 3995) with good ADME and safety profiles. Following MD simulations, these demonstrated better stability and binding free energy in comparison to references based on PCA, FEL, RMSD, RMSF, Rg, SASA, hydrogen bonds, and SASA. These four discoveries show promise as DprE1 inhibitors for the treatment of tuberculosis, but they still need additional *in vitro* and *in vivo* testing.

Trastuzumab Conjugated Drug-loaded PEGylated pH-sensitive Liposomes (TPPLs) for Breast Cancer: Development, Characterization and *in vivo* Assessment

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To develop and characterize trastuzumab conjugated Paclitaxel and Elacridar loaded PEGylated pH-sensitive liposomes (TPPLs) for the effective treatment of HER-2 positive breast cancer.

The liposomes were prepared by the thin-film hydration method. The trastuzumab was conjugated with Mal-PEG2000-DSPE by incubating overnight at 4˚C. Finally, after lyophilization the trastuzumab-PEG2000-DSPE was obtained. The trastuzumab-PEG2000-DSPE was incubated with PEGylated liposomes at 4˚C to form TPPLs.

TPPLs undergo characterization such as vesicle size, PDI, and zeta potential, which were found to be 122±1.6nm, 0.252±0.07, -8.13±0.5 mV respectively. The entrapment efficiency of Paclitaxel (PTX) and Elacridar (ELA) were found to be 76.89 % and 56.33 % in PEG-Ls and 78.96% and 58.63% in TPPLs. The *in vitro* drug release study of both formulations (PEG-Ls and TPPLs) showed enhanced cumulative drug release at acidic pH 5 as compared to drug release at physiological pH 7.4. Further, the *in vitro* cytotoxicity studies were performed in SK-BR-3 and MDA-MB-231 cell lines. The IC_{50} value of TPPLs in SK-BR-3 cells was lower (1.02 µg/ml) than that of PEG-Ls (4.11 µg/ml) while there was no difference in IC_{50} value of TPPLs (4.05 µg/ml) and PEG-Ls (4.25 µg/ml) in MDA-MB-231 cells. The cellular uptake study of FITC-loaded TPPLs and FITC-loaded PEG-Ls was performed in MDA-MB-231 and SK-BR-3 cell lines. Furthermore, the *in vivo* studies of TPPLs showed minimum toxicity profile, minimum hemolysis, higher tumor tissue distribution, and superior antitumor efficacy as compared to other formulations. These studies confirmed that TPPLs are safe and efficacious for the treatment of breast cancer.

In Silico Design and Evaluation of Benzothiazole Derivatives as Potential Anticancer Agents

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Drug resistance and adverse events constitute significant drawbacks of anticancer therapy, which can be addressed by targeted therapy. Development of new drug candidates for cancer therapy is essential for addressing resistance, to improve the efficacy and safety of treatment and also can be useful in expending treatment options. Benzothiazole and its numerous derivatives of electron-rich aromatic heterocycles with endocyclic sulphur and nitrogen atoms have attracted the ongoing interest of synthetic chemists due to their unique properties. In silico studies are transforming the landscape of drug development by offering cost-effective, rapid, and ethical alternatives to traditional methods. Their ability to predict drug behaviour accurately enhances the efficiency of discovering new therapies while minimizing risks associated with human and animal testing.

In the present research work, we have selected series of compounds from various literatures on the basis of their biological activity (IC_{50}) against the cancer cell line MCF-7, prepared their dataset using Chemdraw ultra 17.0 and performed *In-silico* studies such as 3D-QSAR using Sybilx 2.1.1 and ADME studies using SWISS ADME web server.

In present work we had generated 3D-QSAR model which is helpful in identifying potential drug candidates before synthesis, thus saving time and resources in the drug development process. ADME studies are useful in identifying the favourable pharmacokinetic profile for drug candidates also plays vital role in the selection of the suitable drug candidates for development of new drug molecules.

Formulation and Evaluation of Embelin Loaded Gelatin Microsphere for the Treatment of Lungs Cancer

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The purpose of the study is to design and evaluate Embelin loaded gelatin microspheres (E-GMS) for effective drug delivery to the lung. E-GMS was prepared by the emulsification-linkage technique and the formulation was optimized by orthogonal design. The mean encapsulation efficiency and drug loading of the optimal E-GMS were 75.5 ± 3.82 % and 6.15 ± 0.44%, respectively. The E-GMS presented a spherical shape and smooth surface with a mean particle diameter of 18.9 μm. The *in vitro* drug release behavior of E-GMS followed the first-order kinetics. The tissue distribution showed that the drug concentrations at lung tissue for the E-GMS suspension were significantly higher than those for the Embelin solution, and the Ce for lung was 36.19. Histopathological studies proved E-GMS was efficient and safe to be used as a passive targeted drug delivery system to the lung. Hence, E-GMS has a great potential for the targeted delivery of Embelin to the lung.

Green Synthesis, Spectroscopic Characterization and Computational Analysis of Fused Indole-Chalcone derivatives Against Breast Cancer: Integrating DFT, Molecular Docking, MD Simulations and ADME Analysis

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Breast cancer is the most prevalent cancer in females, accounting for 40% of new cancer cases, making it the second leading cause of cancer deaths in female patients. There are several chemotherapeutical medications for the treatment of cancer. However, they are associated with some drawbacks like, toxicities, cancer resistance and adverse effects. In recent years, extensive research has been done in the field of Anti-cancer drug development. Since indole nucleus has shown quite good response as an anticancer agent, hence this nucleus has become an interest in the field of research. Vinca plants contain indole, which has anti-cancer properties. In light of this, indole has been investigated as a potential lead in cancer treatment.

In the present research study, an effort was done in synthesis of new indole-chalcone derivatives 1-7, Green approach assisted by a microwave device. Different spectroscopic instruments were used for their analysis and confirmed their chemical structures. DFT, MEP and *in-silico* investigations has been done by computational tools.

Density function theory, Electrostatic potential maps, Frontier molecular orbital analysis indicated differential stability across the compounds, with compound Ic exhibiting the highest stability and compound Ib the lowest. Molecular docking studies targeting the receptor (PDB: 1SA0) affirmed the high binding affinity of these compounds for the target protein. Molecular docking score -8 to -11 kcal/mol, Subsequent molecular dynamics simulations over a 200 ns revealed that the protein had navigated through a minimal energy basin and demonstrated favorable conformation while binding to the proposed inhibitors. These findings underscore the significant potential of compounds for anticancer therapy, providing a solid foundation for subsequent drug development.

Formulation Development and Evaluation of Herbal Ointment for the Management and Treatment of Alopecia

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The aim of the current study is to explore the development and efficacy of a meticulously crafted herbal ointment utilizing extracts from traditionally recognized hair growth promoters. The chosen botanicals included *Ocimum sanctum* (renowned for its antioxidant and anti-inflammatory properties), *Lawsonia inermis* (offering diverse benefits such as hair shaft strengthening and hair loss prevention), *Trigonella foenum-graecum* (rich in proteins and nutrients for hair root fortification and growth promotion), and *Carissa carandas* (containing flavonoids and terpenoids known to stimulate hair follicles and promote growth).

The study revealed that the herbal ointment, particularly at higher concentrations (1% and 2%), significantly accelerated the initiation of hair growth and reduced the time to full growth, demonstrating comparable efficacy to the standard treatment (2% minoxidil). Both concentrations also exhibited an increase in hair weight, suggesting potential for enhanced hair density. Notably, the 1% ointment displayed promising results as early as 30 days of treatment.

In conclusion, this study provides compelling evidence for the potential of a meticulously formulated herbal ointment as a promising therapeutic approach for hair loss management. Further research is warranted to elucidate the precise mechanisms of action and optimize treatment strategies for maximized efficacy.

Niosomal Formulation of HA-Conjugated Imiquimod: Advancing Topical Treatment of Non-Melanoma Skin Cancer

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Skin cancer is among one of the most common human malignancies wide-spread world-over with mortality statistics rising continuously at an alarming rate. The increasing frequency of these malignancies has marked the need for adopting effective treatment plan coupled with better and site-specific delivery options for the desired therapeutic agent's availability at the affected site. Imiquimod, a topical immune response modifier, has shown efficacy in treating non-melanoma skin cancers by stimulating the immune system to target and destroy tumor cells. However, its clinical application is limited by poor skin penetration and local irritation. To enhance the therapeutic potential of imiquimod, hyaluronic acid, has been explored as a conjugate to improve drug delivery and minimize side effects.

In this study, we investigate the development of a hyaluronic acid-conjugated imiquimod niosomal gel formulation for targeted treatment of skin cancer. The conjugation of HA to imiquimod incorporate in niosomes facilitates enhanced skin penetration, Niosomes were prepared by Thin film hydration method. The prepared niosomes formulation was optimized for various parameters like span 60-cholesterol ratio, hydration volume, temperature to obtain better size of niosomes. Then optimized niosomes further incorporated with conjugated HA-IMQ drug was carried out by formation of amide bond. The formulation was further characterized on the basis of particle size, PDI and *In vitro* drug release studies.

Optimized formulation was selected for further optimization process as it showed optimum size of 576 nm. In vitro drug release profiles were also carried out. Conjugated Formulation shows better drug release profile. Developed formulation enhances the retention time as well as penetration of drug in skin. This further reduces the dosing frequency and ultimately increases the patient compliance.

Design, In-silico Screening, Synthesis and Pharmacological Evaluation of New Methylenedioxyphenyl Derivatives as Antioxidant and Anticancer Agents

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Cancer is a leading cause of death worldwide, accounting more than ten million deaths per year. Rate of morbidity and mortality is increasing day by day. Therefore, A novel series of Methylenedioxyphenyl linked with 3,4,5- trimethoxyphenyl/ 2,5- dimethoxyphenyl/ 4-methoxyphenyl and pyrazoline have been designed, synthesized and characterized by sophisticated spectroscopic techniques. The cytotoxic potential of the title compounds was evaluated in in-vitro bioassay paradigms.

A novel class of Methylenedioxyphenyl derivatives was docked by using Autodock vina software to reveal the interactions of these compounds with the active sites of DNA topoisomerase-II with PBD ID 5GWK. In addition of above, in-silico predictions of pharmacokinetic, and toxicity parameters were also implemented for best compounds. The resulting best compounds were synthesized from simple, versatile, and efficient synthetic methodology. The potential for in-vitro cytotoxicity of each synthesized compound was examined.

Many Derivatives were identified to more active than the standard drug etoposide in docking studies using DNA topoisomerase-II (PBD ID 5GWK). ARG487, MET762, PRO803, GLY462, DG13, DC8, and DT9 were found to be essential residues for the interaction between the ligand and binding pocket of DNA topoisomerase-II receptor. The results of the screening revealed that compounds A1, A3, A6, A7, A10, A13, A17, and A21 were more active candidates of the series. Eight compounds were evaluated for anticancer activity against MCF-7, HepG2, HeLa, DU145, and A549 cell lines and for anti-oxidants activity using DPPH radical scavenging activity. Hopefully in future, compound A7 could be used as a lead compound for developing new anticancer agents.

Organogel Mediated Co-delivery of Quercetin and Beta Sitosterol: A Synergistic Approach Against Skin Cancer

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Skin cancer constitutes a major global health issue, highlighting the need for the advancement of novel therapeutic approaches. This research focused on developing a new combinatorial topical therapy that encapsulates Quercetin and Beta sitosterol within a single nanosized organogel system (QB-OG). This localized therapy utilizes the combined anticancer and antioxidant properties of bioactive compounds, potentially enhancing efficacy while minimizing systemic side effects.

The QB-OG formulation was developed through a systematic encapsulation technique, which ensures stability, optimal drug loading, and sustained release. Characterization studies were conducted to assess the morphology, physicochemical properties, encapsulation efficiency, and release kinetics of the formulation. A skin irritancy study was conducted to evaluate its safety and suitability for topical application, confirming its non-irritant profile.

The improved QB-OG exhibited significant encapsulation efficiency and a regulated drug release profile, suggesting its potential for extended therapeutic efficacy. In vitro experiments demonstrated significant anticancer action, highlighting the synergistic effectiveness of Quercetin and Beta sitosterol. Moreover, the organogel demonstrated superior skin compatibility, with no notable irritancy detected during the safety assessment. These findings underscore the potential of QB-OG as an effective topical delivery strategy for addressing skin cancer. This formulation establishes a robust basis for subsequent clinical investigations, providing a unique method to improve patient outcomes and overcome the shortcomings of traditional medicines.

Computational Design and Molecular Docking Analysis of Novel Anti-Tubercular Compounds

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This study investigates the potential of benzoic acid derivatives as anti-tuberculosis agents by evaluating their binding affinity with the target protein enoyl reductase (InhA) of Mycobacterium tuberculosis and analyzing their pharmacokinetic properties. Current tuberculosis treatments are often associated with adverse effects such as ototoxicity, peripheral neuropathy, and hepatotoxicity. InhA plays a crucial role in the biosynthesis of mycolic acids, which are essential components of the M. tuberculosis cell wall, making it a key target for therapeutic intervention.

A series of 47 molecules were developed by modifying specific quinazoline derivatives, previously known for their potent anti-tubercular properties. Pharmacokinetic properties of these compounds were evaluated using Swiss ADME software. To further assess their efficacy, the designed molecules were subjected to molecular docking studies using Molegro Virtual Docker, focusing on their interactions with amino acids in the target protein. The binding site's active sphere was defined with a radius of 15 Å and dimensions along the XYZ axis.

The results revealed that several of the developed compounds exhibited favorable amino acid interactions, indicating their potential as effective anti-tuberculosis agents. This research provides valuable insights into the design of novel drugs for tuberculosis treatment. The amino acid interactions of the designed molecules demonstrated superior efficacy compared to standard drugs such as isoniazid, ethambutol, and pyrazinamide.
The amino acid interaction of the best molecules are 1G (Met 155, Pro 156, Leu 218, Gln 214, Met 103, Leu 207, Gly 104, Ala 157, Ile 215, Met 199), 1I (Gly 104, Met 103, Leu 207, Ala 157, Ile 215, Phe 149, Met 155, Leu 218, Gln 214, Pro 156), and 2H (Leu 218, Pro 156, Met 155, Gln 214, Met 103, Leu 207, Gly 104, Ala 157, Ile 215, Met 199).

Tailoring the Frequency Response of Thin Permalloy Nanodisk by Modulating the Geometry; a Micromagnetic Investigation

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Frequency response of ferromagnetic materials with different geometries are explored to integrate them into spintronics. An efficient way of tuning the frequency is by changing the shape. So, the dynamic susceptibility of nanodisk is performed by modulating the surface geometry to analyse the effect of modulation for in-plane and out-of-plane pulses.

Micromagnetic simulation is an effective tool to compute the magnetic behaviour before expensive experimental fabrication of complex geometries. Permalloy ($Ni_{80}Fe_{20}$) is selected as the material as the magnetocrystalline anisotropy is negligible. Therefore, the shape dependent dynamic properties can be explored effectively without the interference of material anisotropic properties.

A single vortex gyrotropic mode and several resonance modes with azimuthal symmetry are obtained for the field along x-direction for convex nanodisk. The frequency of the gyrotropic mode shifts to higher values when the geometry is changed to concave. Two higher order excited peaks are initially merged into single peak with two dips and later change into two separate peaks with decrease in radius for this concave geometry. Appearance and disappearance of new peaks is observed for in-plane pulse. For the field along z-direction, there are three excited modes with axial symmetry. Shifting the frequency towards higher values can be done by decreasing the radius. The spatial distribution of Fast Fourier Transform of real component of axial magnetisation is done at the resonant frequencies of the excited modes to understand the area of resonance that responds the most to a particular frequency. The present study shows that tailoring desired frequency is possible through the selection of appropriate geometry. The multi-resonance peak behaviour of the modulated nanodisks can find applications in microwave spintronic devices as comb filters.

PVDF-Metal Oxide Hybrid Films: Fabrication Techniques and Performance Evaluation

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This research paper included the synthesis, characterization and application of PDVF-metal-oxide film. Polyvinylidene fluoride (PVDF) is a fluoropolymer with remarkable properties that have led to its widespread application in various fields. PVDF exhibits a high degree of chemical resistance, thermal stability, and mechanical strength, making it suitable for demanding environments.

In this research, there was discussion about the formation of nanocomposite by the combination of PVDF and metal oxide. These nanocomposites then further go for the film preparation by different techniques, such as film casting, etc. Here, characterization techniques like UV, XRD etc., were being used to observe the structure, chemical properties, and other physical properties of this nanocomposite film. Researchers investigated the structural and electrical properties of PVDF-metal oxide nanocomposite films and also analyzed these tailoring properties to support their applications. PVDF-metal oxide nanocomposite films find applications in various fields, such as sensors, actuators, energy harvesting devices, flexible electronics, and biomedical devices. Their flexibility and biocompatibility make them promising candidates for biomedical applications, including tissue engineering scaffolds and implantable sensors. Overall, PVDF-metal oxide nanocomposite films represent a versatile class of materials with immense potential for technological advancements across diverse fields, driving ongoing research efforts to further explore their properties and applications.

Influence of Chemical Purification Methodologies on the Bridgman Growth of Trans-Stilbene Crystal, and Feasibility Studies for x-ray Imaging and Neutron/gamma Discrimination Applications

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Radiation detection is essential in fields such as medical imaging, nuclear security, material inspection, and homeland security. Organic scintillators like trans-stilbene are widely used due to their fast decay time and excellent Pulse Shape Discrimination (PSD) capability, making them suitable for neutron detection. However, conventional solution growth methods are time-consuming and unsuitable for large-scale production. This study aims to grow high-quality trans-stilbene crystals using the Bridgman technique, providing a more efficient and scalable alternative for advanced radiation detection and imaging applications.

Trans-stilbene crystals were grown in a two-zone furnace using the Bridgman method. To improve optical quality, the starting material underwent double purification (recrystallization and zone melting) before crystal growth. The grown crystals were cut and polished for structural (XRD, HRXRD), optical (birefringence interferometry, UV-Vis spectrophotometry), and scintillation studies (PL, TCSPC, X-ray luminescence, and PSD). X-ray imaging experiments were conducted at the Imaging beamline (BL-04) of the Indus-2 Synchrotron Radiation Source at RRCAT. The PSD performance was evaluated using an Am-Be neutron source, a PMT, and a CAEN DT5790 digitizer.

Large, crack-free, transparent crystals with high optical quality and a band gap of 3.47 eV were successfully grown. Photoluminescence studies showed a broad emission peak at 380 nm under 325 nm excitation, with dual decay times of 1.98 ns and 4.14 ns. The crystal exhibited strong scintillation output, high-resolution (100 µm) x-ray imaging, and effective n/γ discrimination. These findings confirm that Bridgman-grown trans-stilbene is a promising material for neutron detection and radiation imaging, offering a viable alternative for large-scale production.

Studies on Initiation of Modelocking Operation in Fiber Mamyshev Oscillator

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Mode-locked fiber lasers are receiving increased attention due to their diverse applications ranging from basic research like spectroscopy to state-of-the art industrial applications such as communication and micro-machining. A mode-locked pulse is generated by a balance of gain, loss, dispersion and nonlinearity in the oscillator. Recent interest is in a new oscillator named, Mamyshev oscillator (MO) due to its simple construction, higher environmental stability and tolerance towards nonlinear phase shift.

MO is based on alternate nonlinear spectral broadening and offset spectral filtering in the cavity. Offset filters prevent optical fluctuation and feedback in the cavity and, consequently, onset of modelocking. Thus, an external seed is usually injected to start modelocking in MO. Operation of MO with an external seed source makes MO to lose its attraction. Hence, a continued search to devise a method/mechanism is going to self-start the MO.

In this work, development of fiber MO in the lab and studies on self-starting, single to multi-pulse patterns and role of external seed parameters on pulse evolution dynamics in fiber MO is presented. First, a fiber MO is developed and to initiate pulse operation in MO, a lab made modelocked seed source is used. Role of seed source parameters was studied in detail and found that there exists an optimum spectral width of the seed source for which probability of generating mode-locked stable single pulse from MO is maximum. Later, in the quest to devise a simple mechanism to self-start the modelocking process in MO, we investigated a simple method that requires only an optical beam shutter (OBS) instead of an external seed source. OBS generates a strong fluctuation in the MO cavity, which at a proper filter separation generates stable modelocked pulse operation in MO. MO generates ~175 fs duration pulses at ~1 μm wavelength and ~10 MHz repetition rate. Such oscillator can be used for bio-medical imaging and can serve as stable source for further power/energy scaling in amplifiers.

Extracting the Global 21-cm Signal using Gaussian Process Regression

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The Epoch of Reionization (EoR) and Cosmic Dawn (CD) are pivotal stages in the early evolution of the Universe, influencing its structural development during its initial billion years. The characteristics of the Intergalactic Medium (IGM) during the EoR and CD are yet to be firmly established through observation. Current and upcoming radio telescopes, such as EDGES, SARAS, MWA, and SKA, aim to capture the redshifted HI 21-cm signal yet face challenges due to systematic errors and the necessity for precise foreground removal. Moreover, the Earth's ionosphere introduces distortions at lower frequencies, including direction-dependent and chromatic effects of the primary beam, complicating the detection of the global 21-cm signal.

In this study, we have developed a machine learning technique utilizing Gaussian Process Regression (GPR) to extract the global 21-cm signal, which is heavily obscured by foregrounds that are 10^4 to 10^6 times brighter. Here, we trained this ML model on datasets containing signal and foreground and their corresponding parameters. Once the model has been trained, the trained ML model is applied to unseen test datasets to infer both the global 21-cm signal and foreground parameters.

The model achieves prediction accuracies ranging from 80% to 98% for signal parameters and 83% to 98% for foreground parameters. A key advantage of this approach is its ability to infer parameters along with associated uncertainty estimates, making it especially valuable for accurately understanding the astrophysical processes of the early Universe. Additionally, the model is computationally more efficient than traditional inference methods, facilitating the effective exploration of high-dimensional parameter spaces. This approach shows considerable promise for improving ground-based observations, enabling precise recovery of signal parameters from both Cosmic Dawn and the Epoch of Reionization.

Effect of Relativistic electron Mass Variation and Phase Mismatch on IR Parametric Generation in Semiconductor Magnetoplasma

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Accessibility of high frequency lasers makes it essential to consider relativistic effects on nonlinear interaction studies. Phase Matching in any nonlinear wave mixing process facilitates maximum energy transfer from the pump field to the signal field leading to maximum spatial period of the oscillations. But the efficient energy conversion critically depends on the relative phases between the interacting waves. These dispersion effects may cause many destructive aspects of phase mismatch. In order to inspect phase mismatch effects on IR parametric generation in magnetised doped semiconductor plasma.

An analytical investigation is made for relativistic electrons using hydrodynamic model and coupled mode theory. The threshold value of pump electric field and the corresponding excitation intensities are obtained for the onset of parametric generation in magnetised doped semiconductor plasma medium. The theoretical formulation obtains induced polarisation due to induced nonlinear current density and corresponding second order optical susceptibility in piezoelectric medium which infact is the origin of Infrared parametric generation.

Data of n-InSb crystal at 77 K duly irradiated by 1.06 μm Nd: YAG laser is used for numerical estimations. It is found in our study that the minimum threshold value of pump electric field Intensity I_{th} in presence of relativistic parameter Γ and a constant phase mismatch parameter Δk is about 1.5×10^{7} W/m^{-2}, at which the onset of parametric generation can be achieved readily, this finding provides cost effectiveness of optical device based on nonlinear effects. Present study explores possibilities of utilising engineered dispersion to enhance nonlinear optical effects for generating new light frequencies and significantly altering the light propagation and dispersion properties of the semiconductor medium.

Role of Annealing Temperature on the Critical Current Density of the $V_{0.59}Ti_{0.40}Ce_{0.01}$ Alloy Superconductors Prepared by Successive Cold-working and Annealing

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The V-Ti alloys are potential alternatives to the Nb-Ti alloys for high-field applications. The addition of rare-earth elements to $V_{1-x}Ti_x$ alloys, followed by successive cold working and annealing (SCA), is found to improve the critical current density (J_C) significantly [Ramjan et.al., *J.AllCom.* **976,** 173321 (2024)]. However, optimal annealing temperature to get maximum J_C needs to be explored. Therefore, here we compare the J_C achieved after SCA at 450°C, 550°C and 650°C.

SCA was carried out on arc-melted $V_{0.59}Ti_{0.40}Ce_{0.01}$ alloys, where the samples were cold-rolled to 50% of their thickness (CW1) and annealed (at 450°C/ 550°C/ 650°C) for 5 hours (Ann1). This process was repeated twice more, resulting in CW3 and Ann3. The effect of SCA on the $V_{0.59}Ti_{0.40}Ce_{0.01}$ alloy is studied by comparing the microstructure, electrical resistivity, and J_C.

SCA at 550°C on the $V_{0.59}Ti_{0.40}Ce_{0.01}$ alloy produces a multi-phase microstructure with primary β-$V_{0.60}Ti_{0.40}$ phase and secondary cerium oxides, ω, and α' phases. The maximum zero-field J_C (4K) of the $V_{0.60}Ti_{0.40}$ alloy is only about 1×10^8A/m^2. However, with the addition of 1 at.% Ce in the $V_{0.60}Ti_{0.40}$ alloy, J_C (4K) increases to 4.35×10^8A/m^2 in zero magnetic field and 1.6×10^4A/m^2 in 7T field. After one cycle of SCA at 550°C, the J_C (4K) increases to 1.61×10^9A/m^2 in zero-field and 3.38×10^7A/m^2 in 7T for Ann1 sample. SCA at 450°C improves the zero-field J_C (4K) to 4-8$\times10^9$A/m^2 and to about 4×10^8A/m^2 in 7T field for CW3 and Ann3 alloys, respectively. In contrast, for SCA at 650°C, J_C (4K) of the CW2 sample increases to 4.87×10^9A/m^2 and 7.39×10^7A/m^2 in zero-field and 7T, respectively [Asi et.al., *J.Supercond.Nov.Magn*, **38**, 34 (2025)]. While SCA at 450°C achieves one-fourth the J_C of commercial Nb-Ti alloys in three steps, similar results are obtained in one step at 550°C. However, J_C improvement at 650°C is significant only in low fields.

Study of Green Synthesized Pure and Copper-doped Zinc Oxide Nanoparticles

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Zinc oxide (ZnO) is one of the most commonly studied metal oxides, known for its versatile and extraordinary properties, making it suitable for a wide range of applications, including biomedical, antimicrobial, photocatalytic, antidiabetic, antiviral, food industry sensors, drug delivery systems, and nanotechnologies. Transition metals, such as copper, are excellent candidates for doping materials. In this study, copper was used as a doping agent to enhance the properties of ZnO nanoparticles.

Pure ZnO and copper-doped ZnO nanoparticles were synthesized using a modified green synthesis method, in which the temperature was varied during the synthesis process. In this method, Azadirachta indica (Neem) leaves were employed as stabilizing, reducing, and capping agents, while zinc and copper salts served as precursors.

The structural, morphological, and optical properties of the pure and Cu-doped ZnO nanoparticles, at doping concentrations of 2% and 4%, were analyzed using powder X-ray diffraction (PXRD), scanning electron microscopy/energy-dispersive X-ray (SEM/EDX), UV-Vis, and FT-IR spectroscopy. Powder XRD spectra showed broad characteristic peaks for ZnO nanoparticles, with the crystallite size decreasing from 16.58 nm to 15.69 nm and further to 15.01 nm. The characteristic peaks shifted towards the origin, and the interplanar spacing increased. UV-Vis spectroscopy revealed a decrease in the band gap with increasing doping concentration, with values of 3.14 eV, 3.11 eV, and 3.08 eV, and absorption wavelengths at 394.9 nm, 398.7 nm, and 402.5 nm, respectively. SEM images exhibited spherical and rock-like structures of the nanoparticles in the 1-micrometer range. EDX analysis confirmed the formation of ZnO nanoparticles and Cu doping within the ZnO matrix. FTIR spectra showed characteristic ZnO stretching at 518 cm^{-1} and CuO stretching at 654 cm^{-1}. Other functional groups, such as O-H stretching and bending, as well as C-N stretching bonds, were also observed in the green-synthesized pure and Cu-doped ZnO nanoparticles.

Asymmetric Edge Hydrogenation and Fluorination Passivation of Zigzag Germanium Selenide Nanoribbon for Metal Interconnect Application: A First-Principles Study

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Asymmetric (selective) edge passivation is one of the prevalent (practical methods) methods for electronic/magnetic properties modification of nanoribbons. On the basis of selective edge passivation, various applications of nanoribbons are explored in the areas of spintronics, nanoscale metal interconnects, sensors, transistors, etc. Hence, in the present study, we have primarily focused on the investigation of asymmetric (selective) H-passivated and F-passivated Zigzag Germanium Selenide Nanoribbons (ZGeSeNRs) for metal interconnect applications.

Theoretically, we have designed the asymmetric edge ZGeSeNR passivated with H and F by using the Quantum Atomistic ToolKit, in which we deployed density functional theory (DFT) and Non-equilibrium Green Function (NEGF). Firstly, we optimized asymmetric edge configurations, and after optimization, we then calculated their structural, electronic, and transport properties.

Further, we observed that the asymmetric edge passivated (H and F) configurations are thermodynamically stable, based on negative values of binding energy (E_b), and can be experimentally realized using various techniques. The structural properties gave the stability of nanoribbons; the more negative the value of binding energy (E_b), the more stability they have. Owing to a conducting electronic character based on band structure analysis and density of states (DOS) profile for asymmetric edge passivated ZGeSeNR. These configurations were studied to examine crucial static and dynamic parameters (such as R_Q, L_K, and C_Q), and the number of transmission channels (N_{ch}) on which these parameters depend was also calculated. We observed that the minimum values for all the parameters with R_Q (4.31 K-ohm), L_K (5.97 nH/μm), and C_Q (12.91 pF/cm) for F-8z-GeSeNR-F configuration, hence, this configuration emerges as the promising choice for nanoscale metal interconnect.

Magnetoelastic-Based Colossal Terahertz Phase Shifter For 6G and Beyond Terahertz Communication

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Terahertz (THz)-based communication is expected to become a reality, facilitated by the development of functional devices like filters, mixers, polarizers, and modulators. Essential to this advancement is the steering of THz radiation, which necessitates an efficient phase shifter.

In the THz electromagnetic spectrum, we investigated a novel class of materials, which inherently enables a colossal THz phase shift. To unveil this, we have performed magneto-THz spectroscopy experiments on the magnetoelastic system $Ba_3BiX_2O_9$ (X = Ir, Ru), prepared using the solid-state reaction method.

In this study, we introduce a novel mechanism that utilizes the intrinsic property of magnetoelastic coupling to achieve colossal THz phase modulation. We observe an unprecedented THz phase shift of ~600º at ~0.9 THz in $Ba_3BiIr_2O_9$ during the magnetoelastic transition at ~72 K. This was accompanied by a figure-of-merit four to five times greater than existing free-space phase modulators with shifts exceeding 90º. Theoretical calculations support our findings, indicating that spin-phonon coupling dynamics play a crucial role in modifying the underlying dielectric function. We further explored this magnetoelastic mechanism in $Ba_3BiRu_2O_9$, which exhibited a giant THz phase shift of 565.96º at 0.75 THz, with a linear phase-frequency relationship from 0.10 to 0.75 THz during the magnetoelastic transition at ~165 K, nearly double that of $Ba_3BiIr_2O_9$. Additionally, we highlight the rare magnetic-field control of THz phase shifting in these materials. Finally, we propose a proof-of-concept for a MODEM (modulation and demodulation) system for THz communications, underscoring its potential impact on next-generation THz photonics.

DFT Examination Conveys Fascinating Structural, Electronic, Elastic, Thermoelectric, and Optical Attributes of Strontium-based Halide Perovskites $SrCuX_3$ (X = Cl and Br)

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Density functional theory unveils the structural, optoelectronic, and transport characteristics of $SrCuX_3$ (X=Cl, Br) perovskite compounds. The Birch-Murnaghan equations of states have been used to verify the structural stability of both the compounds under discussion. These equations show that both compounds exhibit structural stability because their ground-state energy levels are negative. The structural investigation confirms that these compounds are cubic with space group Pm-3m 221 and display stability. The band structures and the band gap of 2.15 eV and 1.75 eV were estimated for the electronic attributes, revealing that both compounds are semiconducting. Elastic constants: bulk modulus (43.03, 36.66), Poisson's ratio (0.39, 0.36), anisotropy factor (0.36, 0.60), and Pugh's ratio (4.21, 3.48) are examined for the study of elastic features. Pugh's ratio characterizes the compounds' ductility, and the Cauchy pressure can be used to identify their ionic nature. Numerous optical attributes comprising refractive index, absorption coefficient, dielectric function, reflectivity, extinction coefficient, and optical conductivity have been reviewed in the incident photon energy ranges of 0 eV to 13 eV. Maximum light absorption strikes these compounds between 5 and 13 eV of incident photon energy. As a result, these materials act as strong light absorbers, they can be employed in high-frequency optoelectronic devices. The thermoelectric properties of the investigated compounds have been calculated using the BoltzTraP code, which has been patched with the WEIN2K code. $SrCuX_3$ (X=Cl, Br) is a promising choice for thermoelectric applications because it has a higher Seebeck coefficient, strong electrical conductivity, and a figure-of-merit; zT is close to unity.

Statistical Analysis of Severe Geomagnetic Storm and its Effect on foF2 at Low Latitude during 25th Solar Cycle

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The F2 layer affects radio propagation and communication systems, influenced by solar and geomagnetic activity. Geomagnetic storms degrade satellite communication and GPS, particularly at low latitudes, highlighting the need for better space weather prediction.

The present study aims to statistically analyze the effects of super intense geomagnetic storms, on foF2 with geomagnetic indices investigated at the low-latitude station Darwin (12°27'40.1" S, 130°50'511" E) during the 25th solar cycle. This study is based on the critical frequency of the F2 layer(foF2), used to study super intense geomagnetic storms that occurred on May and October 10-11, 2024.

FoF2 data were obtained from GIRO (Global Ionospheric Radio Observatory) at giro.uml.in, and geomagnetic data were sourced from the OMNI Web online data services interface (https://omniweb.gsfc.nasa.gov).

It was found that the Dst index for the May and October 2024 geomagnetic storms peaked at -412 nT and -333 nT, respectively. The highest value of the Kp index was 9 and 8.3, respectively, while the Ap index was 40 nT and 23 nT. It was observed that the daily averaged values of solar flux (10.7) and foF2 were inversely related. These storms have a negative effect on Earth's magnetic field, which can interfere with GPS systems, radio transmissions, and power grids. Understanding the dynamics of geomagnetic storms is crucial for enhancing resilience against space weather disruptions in the future.

A Way to Enhance the Conductivity of (PAN-PVA) +$LiCF_3SO_3$ Based Blend Salt Complex by Incorporating Different Ceramics

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In the present work, PVA (92.5%) - PAN (7.5%) + LiCF3SO3 (50wt%) has been used as a blend salt complex. The polymer blend-salt complex system shows conductivity of 2.12×10^{-4} S cm^{-1} at room temperature. To further increase the conductivity $Li_{1.3}Al_{0.3}Ti_{1.7}(PO_4)_3$, $Li_{1.3}Al_{0.3}Zr_{0.1}Ti_{1.6}(PO_4)_3$, and $Li_{1.3}Al_{0.5}Nb_{0.2}Ti_{1.3}(PO_4)_3$ has been used in different wt.% (20 wt.%, 30 wt.%, 40wt%). The optimised blend–salt ceramic composite shows conductivity of 7.48×10^{-4} S cm^{-1} and voltage stability of 5.86V. Hence the introduction of active filler has effectively enhanced conductivity and voltage stability in composite solid electrolytes.

Study of Systematics on Foreground Removal Techniques for SKA-low in 21-cm Cosmology

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In an attempt to track our Universe's past, one of the most prominent gaps in our understanding is the period of the "Cosmic Dawn." The period extends for about 50 million years to one billion years after the Big Bang when the first stars, black holes, and galaxies in the Universe formed. One of the best ways to observe this era is with low-frequency radio telescopes, which can observe the redshifted "spin-flip" radiation from the hydrogen that pervades the Universe during the Cosmic Dawn.

The inception of the upcoming SKA-Low telescope with unprecedented sensitivity is our best bet for detecting the 21-cm signal. However, several challenges complicate the detection of the HI signal, including astrophysical foregrounds and instrumental uncertainties Previous research on SKA-low simulations has indicated that our calibration gain errors as low as 0.1% can contaminate the 2-dimensional cylindrical power spectrum with low SNR, potentially impeding our ability to explore the Epoch of Reionization (EOR) window Therefore, studying the robustness of the present foreground removal techniques against these systematics is essential.

Gaussian Process Regression (GPR) has been used to mitigate residual foregrounds and produce upper limits for LOFAR and HERA. We present some initial results that check the robustness of GPR for SKA-low with calibration gain error-induced point source subtracted visibilities. We anticipate a deviation in the constrained GPR parameters of length scale and variance with varying gain error percentages due to the amount of residual foreground. The spherical power spectrum is expected to be k-dependent with possible over-subtraction for small k-modes. We also conduct a comparative study using traditional 'blind' foreground removal techniques like polynomial fitting and Principal Component Analysis (PCA) concerning signal subtraction. This research is vital for understanding current and future experiments for the first-ever detection of the 21-cm signal.

First-principles Calculations of Structural, Opto-electronical Properties of Double Perovskite $Cs_2AgSbCl_6$ for Solar Cell Applications

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To cover up the world's energy problems, double perovskites (DPs) are good candidates for environmentally friendly energy harvesting. Density functional theory (DFT) calculations have been examined to determine the electronic, optical, and structural characteristics of DP $Cs_2AgSbCl_6$. The structural parameters are determined by the PBE-GGA+TB-mBJ approximation. The calculated lattice constants match perfectly with the experimental data. $Cs_2AgSbCl_6$ material has an indirect bandgap (E_g) of 2.49 eV and shows high absorption coefficient values in the visible and ultraviolet regions, indicating that the opto-electronic properties prove that $Cs_2AgSbCl_6$ material is suitable for solar cell (SC) applications. The calculated static value of the dielectric function at zero energy is computed to be 2.98, and the value of the refractive index at zero energy is determined to be 1.72 for $Cs_2AgSbCl_6$. Results indicated that the electron has a lower effective mass and higher mobility than the hole. In the end, the optical characteristics confirm the material's opto-electronic properties making it a better applicant for perovskite solar cells (PSCs).

The worldwide increases in the usage of energy have inspired researchers to investigate new renewable energy sources. The desired properties of the materials are required to use solar energy, which is the most abundant source of renewable energy, to determine their bandgap and feasibility of application. Therefore, research is investigated for several materials to consider their possible uses in thermoelectric and opto-electronic applications [1, 2]. Due to their low cost and higher efficiency, halide-based DPs are valuable for SC and photovoltaic (PV) technological applications [3, 4]. In 2009, the power conversion efficiency (PCE) of the first halide-based perovskite (PVSK) ($CH_3NH_3PbI_3$) for PV applications was 3.8%. With PCE of 23.6%, Wang et al. studied $FA_{0.83}Cs_{0.17}PbI_{2.7}Br_{0.3}$ [5]. According to a recent study ensures that these Pb-based materials are interesting to investigate for alternative of silicon cells with the PCE of up to 25.2% [6-8]. One of the main problems is the toxicity of Pb, which shows the

Dielectric Behavior of Pure and Malachite Green Doped Polyvinylidene Fluoride Film

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Dielectric behavior of polymeric film is of noticeable interest due to their application for insulation, isolation and in microelectronics. This work has a lot of importance in various aspect. The result obtained will help to understand the mechanism of charge product, storage and transport behavior in the system of pure and doped polymer. In present investigation polyvinylidene fluoride (PVDF) and malachite green (MG) have been used as a host polymer and guest material respectively. Samples have been prepared using solution cast method. Dielectric constant i.e. permittivity ((ἑ), dielectric loss (ε̈) and relaxation time (τ) have been studied as a function of temperature (25-80^{0}C), frequency (100–1MHz) and doping concentration. Dielectric constant i.e. permittivity (έ), dielectric loss (ε̈) and relaxation time (τ) increase with increasing temperature and decreased with increasing frequency for both pure and MG doped PVDF samples. The magnitude of doped samples is higher than pure PVDF. The increase in dielectric permittivity with rise in temperature may be due to an increase in polarization arising from facilitation of molecular motions of chain units in the applied field. This rise in dielectric loss is brought about by an increase both in the conduction of residual current and of absorption current. The increase in dielectric loss with rising temperature seems to indicate migration of trapped charge carriers, thereby increasing contribution from d. c. conduction losses and may be due to charge transfer complexes (CTCs). The decrease in loss on higher frequency is useful for charge storage application.

Design, Synthesis and Evaluation of Polymer Nanocomposites for Gas Sensing Applications

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Thermolysin and aniline, a representative small molecule ligand, aiming to elucidate the binding mode and affinity of the complex. The crystal structure of Thermolysin was utilized as the receptor, and aniline was docked into its binding pocket using computational tools. The docking results revealed specific binding interactions between Thermolysin and aniline, characterized by hydrogen bonding, hydrophobic interactions, and coordination with the active site zinc ion. The predicted binding pose provided valuable insights into the molecular recognition between Thermolysin and aniline, shedding light on the structural basis of their interaction and potential implications for enzymatic activity modulation. This computational study contributes to a deeper understanding of Thermolysin-ligand interactions and holds implications for the rational design of novel inhibitors or substrates targeting Thermolysin for therapeutic purposes.

In the last few decades, serious environmental issues have been aroused due to massive industrialization, which poses continuing risks to human health and environment. The analysis will be focused to meet out the current challenges of sensor industry, like cost effective, low concentration detection, operation at room temperature and reusability for field deployment. Specifically, the sensitivity, selectivity, detection limit and response time, will be measured in terms of various electronic properties. Similarly, it can be used to detect toxic gas sensor, because we can add aniline monomer and nanocomposite to make protein polymer nanocomposite (PPNC). More complex sensing platforms have been developed as a result of recent developments in materials science and nanotechnology, such as protein-polymer-nanocomposite (PPNC)-based sensors.

Field Induced Behavior and Magnetic Ground State of Quasi-one-dimensional Ising frustrated zigzag chain antiferromagnet: $CaCoV_2O_7$

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We introduce $CaCoV_2O_7$ with quasi 1D Ising based frustrated zigzag chain antiferromagnet lattices of cobalt ions in bc-plane with crystal system monoclinic space group of $P2_1/c$.

Through a combination of magnetic susceptibility, specific heat, and neutron diffraction studies, the associated long range magnetic ordering $T_N \sim 3.3$ K has been discovered by our zero-field neutron diffraction studies revealed the up-up-down-down spin structure.

A field-induced spin-flop transition below T_N is found to occur at an applied field of ~3 Tesla. The temperature dependent susceptibility curve also show broad peak, characteristics of the short range magnetic ordering, with $T_{max} \sim 4$ K. The fitting of the susceptibility (χ) curve by S = 1/2 one dimensional (1D) uniform spin-chain Heisenberg antiferromagnetic (AFM) model estimates the nearest neighbor exchange interaction $J/k_B = (4.8 \pm 0.006)$ K.

Interface-driven Switching of Spin Hall Magnetoresistance in Ferromagnetic/high Spin Orbit Coupled Oxide Heterostructures

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Spin Hall magnetoresistance (SMR) arises from the interplay between the spin current in the high spin-orbit coupled (SOC) material and the magnetization of the adjacent ferromagnetic layer. The amount of absorption and reflection of spin currents from the interface with the adjacent ferromagnetic layer determines the sign i.e., positive or negative spin Hall magnetoresistance (SMR). While various mechanism has been envisaged to understand the origin of both the positive and negative SMR, a search for the control parameter to switch the sign of SMR is crucial for the logic operations.

To answer the aforementioned question, we fabricated epitaxial $[(SrRuO_3)_x/(CaIrO_3)_y]_z$ (x = 1,3,4 and 8 y = 1,3,6 and 10, z = 4 and 10) superlattices using pulsed laser deposition onto TiO_2 terminated $SrTiO_3$ (STO) (100) substrates. The thicknesses of the superlattices were precisely controlled/monitored by in-situ reflection high-energy electron diffraction (RHEED). The structural, magnetization and transport characterization has been done by X-ray diffraction, superconducting quantum interference device (MPMS-3) and Physical Properties Measurement System (PPMS) equipped with rotor module respectively.

This study introduces a new class of perovskite superlattice materials for exploring SMR, demonstrating for the first time a thickness-mediated switching the sign of SMR from negative to positive attributed to the competing contributions from the spin-to-charge interconversion at both the interface and the bulk enabled through precise control of $SrRuO_3/CaIrO_3$ heterostructure architecture. In contrast, varying the $SrRuO_3$ layer thickness leads to modulation of magnetic anisotropy - resulting in the complete suppression of SMR. The present study offers a pathway for designing reconfigurable spintronic devices, enabling precise control over spin current flow and resistance states for advanced memory, logic applications and is crucial for developing advanced memory technologies, magnetic sensors, and energy-efficient electronics, while also contributing to innovative research in quantum materials and spin-based signal processing.

A Study on Correlation of M3000f2 and Fof2 at Low Latitude Station Austin During Solar Cycle 25

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The ionosphere is primarily studied using routine ionosonde measurements, with additional insights from in situ data collected by rockets and satellites. Statistical studies, particularly correlational analysis of various ionospheric parameters such as the critical frequency of the F2 layer (foF2) and the propagation factor [M(3000)F2], offer valuable information about the complex phenomena occurring in the ionosphere. This study investigates the correlation between the critical frequency of the F2 layer (foF2) and the propagation factor [M(3000)F2] over the Austin ionospheric station (30°16′11″N, 97°45′25″W) during the year 2023, within solar cycle 25.

Using ionosonde data collected throughout various seasons in 2023, we analyze the diurnal, monthly, and seasonal variations of these parameters and their relationship with magnetic indices. The results indicate a positive correlation between M(3000)F2 and foF2 across diurnal, month-to-month, and seasonal timescales, indicating their joint dependence on ionospheric density and solar radiation. However, monthly variations show a negative correlation. Additionally, our study finds a negative correlation between diurnal variations of ionospheric parameters and magnetic indices. These results enhance our understanding of ionospheric behavior and its response to solar and geomagnetic activity, which is crucial for improving ionospheric modeling and radio communication predictions.

Quantum Plasma Dynamics: Investigating Parametric Instabilities in PZT-Based Semiconductors – A Comprehensive Review

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This work examines wave interaction in a quantum plasma environment and its consequences in bringing about unexpected changes in the behavior of materials. The researchers found that, through mathematical modeling, numerical simulations, and experimentation, parametric instabilities were favorable to the PZT materials.

The implications of this work for burgeoning technologies such as optoelectronics, nanotechnology, and energy systems are rather grave. Finally, quantum plasma dynamics offers another viewpoint into understanding wave interaction with small particles concerning their possible applicability as PZT semiconductors.

This review expands on the knowledge and creates a basis for developing new technologies based on quantum and plasma principles. This also represents a discussion of current issues in the field and emphasizes the difficulties researchers face trying to validate specific hypotheses. By identifying these challenges, the study promotes additional work in developing a computer model and exploring novel applications of PZT materials in quantum plasma environments. The fundamental interactions, instabilities, and nonlinear phenomena that arise in quantum plasma environments are studied using advanced models such as quantum hydrodynamics (QHD). Essentially, quantum plasma dynamics combines two fascinating subjects: quantum mechanics, which deals with the behavior of microscopic particles, and plasma physics, which deals with peculiar types of ionized gases. The present work also elucidates the strange character of lead zirconate titanate (PZT) semiconductors that undergo significant deformation when an applied electric field is placed across them.

Effect of Capping Agent on Structural and Optical Properties of Niobium (V) Oxide Synthesized by Thermolysis Method

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Using a fixed amount of the precursor Niobium pentachloride and a variable amount of the surfactant Polyvinylpyrrolidone, Niobium (V) Oxide NP was produced by thermolysis, a rapid and economical method for producing nanoparticles (NP). To confirm these nanoparticles' crystalline clarity and stoichiometry, X-ray diffraction and Raman spectroscopy were used. The size of the crystallites, as determined by the Scherrer technique, was around 18 to 30 nm. According to diffuse reflectance spectroscopy obtained in the ultraviolet-visible range, the optical band gap values (~3.10, 3.11, 3.13, and 3.14 eV) changed during the crystal formation process. The Raman vibrational modes of the material reveal its orthorhombic phase. Fourier transform infrared spectroscopy (FTIR), which detects the different stretching vibration modes of oxygen and niobium in the spectrum, is used to gather the material's vibrational data. Within a specific range, it was discovered that every sample displayed the fingerprint stretching vibrations.

Development and Characterization of PVDF-Based Hybrid Nanocomposites for Optoelectronic Applications

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Advancements in nanotechnology have facilitated the development of hybrid nanocomposites, which combine the unique properties of organic polymers and inorganic nanoparticles, offering multifunctional capabilities for advanced technological applications. In this study, nanocomposites based on polyvinylidene fluoride (PVDF) were synthesized by incorporating cadmium sulfide (CdS) and zinc sulfide (ZnS) nanoparticles using the co-precipitation method. PVDF, a semicrystalline polymer valued for its chemical resistance, thermal stability, and distinctive piezoelectric and pyroelectric properties, served as the suitable host matrix. Neat PVDF and PVDF/CdS/ZnS nanocomposites were prepared and extensively characterized using advanced techniques. X-ray diffraction (XRD) analysis with Cu-Kα radiation (1.54 Å) revealed a significant reduction in the α-phase and an enhancement of the β-phase, indicating improved piezoelectric characteristics. Fourier-transform infrared (FTIR) spectroscopy confirmed structural modifications, while scanning electron microscopy (SEM) demonstrated the uniform distribution of CdS and ZnS nanoparticles within the polymer matrix. Optical investigations employing UV-Vis spectroscopy demonstrated that as the amount of nanoparticles increased, the bandgap significantly decreased, resulting in improved light absorption. Additionally, photoluminescence analysis revealed a broadening of the spectral-sensitive region upon nanoparticle incorporation, highlighting the synergistic interaction between PVDF and the embedded nanoparticles. This interaction enhanced the mechanical, optical, and piezoelectric properties of nanocomposites, making them promising for solar cells, LEDs, and energy-harvesting devices.
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Raman Characteristics of Yb Doped $YGdVO_4$: A Mixed Laser Gain Crystal

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Ytterbium-doped (Yb^{3+}) vanadates are particularly notable for their relatively large absorption and emission cross-sections. Recently, significant attention has been directed toward the development of disordered laser host crystals, aimed at producing ultrafast lasers. The mixed vanadate crystals with inherent disorder are of particular interest due to their potential to exhibit broad emission, making them important material for advanced solid state laser.

In light of this, the present study focuses on the growth of single crystals of 2.5 at.% Yb-doped $Y_xGd_{(0.975-x)}VO_4$, a mixed vanadate, along the [100] direction using the Optical Floating Zone technique. The ionic radii mismatch of the host ions around the active Yb ions introduces structural disorder, resulting in inhomogeneous broadening and splitting of the spectral lines of rare-earth activators. This disorder also influences the vibrational and Raman spectral lines of the materials, which ultimately impact their laser properties.

In the present investigation, structural disorder in the crystal lattice was investigated using Raman spectroscopy. The disruption of lattice periodicity due to disorder significantly affects the vibrational modes in the host crystal. In orthovanadate, the one of the most prominent Raman modes is the high-frequency $A_{1g}(\nu1)$ mode, which corresponds to the symmetric stretching vibration of V-O in the tetrahedral $(VO_4)^{3-}$ anionic group. Another notable, though weaker, Raman mode observed is $A_{1g}(\nu2)$, associated with the O-V-O bending vibration. In this study, the influence of the Y/Gd ratio on the $A_{1g}(\nu1)$ and $A_{1g}(\nu2)$ Raman modes was examined by analyzing the shifts, intensity variations, and broadening of the Raman bands. The Raman linewidth of the $A_{1g}(\nu1)$ mode observed at around 880 cm^{-1} has been investigated and an increase in the linewidth confirms an enhancement in lattice disorder. Additionally, a blue shift in the Raman peak position was observed as the Y concentration increased in the mixed host crystal.

Study of Electronic Band Structure of Mn-Doped TiO_2 Thin Films

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This study investigates the influence of substrate temperature and manganese (Mn) doping on the structural, surface, and electronic properties of titanium dioxide (TiO_2) thin films synthesized via pulsed laser deposition (PLD). An increase in substrate temperature enhanced the crystallinity of TiO_2 films, transitioning from a single-phase anatase structure to a mixed anatase-rutile phase. Mn doping further induced a mixed phase with improved crystallinity, introducing lattice distortions and a distinct MnO_2 phase, as confirmed by X-ray diffraction (XRD). Raman spectroscopy validated these structural changes, showing shifts and additional peaks associated with strain, defect states, and local lattice modifications caused by Mn incorporation. Atomic force microscopy (AFM) revealed that higher substrate temperatures increased surface roughness due to enhanced grain growth, while Mn doping reduces surface roughness and film thickness. These changes are attributed to altered growth dynamics and surface energy modifications introduced by Mn doping. Raman spectroscopy supported this observation, highlighting defect-induced suppression of grain coalescence and smoother film morphology in Mn-doped TiO_2 samples. Valence band spectroscopy (VBS) confirmed the presence of defect states Ti^{3+} and oxygen vacancies in Mn-doped films, resulting in significant electronic structure modifications. These defects play a critical role in tailoring the functional properties of TiO_2 thin films. This study demonstrates the combined effects of substrate temperature, Mn doping on the electronic properties of TiO_2 thin films. The findings provide valuable insights into optimizing TiO_2 for applications in energy conversion, photocatalytic by leveraging controlled growth parameters and dopant-induced modifications.

^{119}Sn Nuclear Forward Scattering and Synchrotron Radiation Perturbed Angular Correlation Study of Relaxor Ferroelectric $BaTi_{0.7}Sn_{0.3}O_3$

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Lead-free Barium titanate ($BaTiO_3$, or BTO) based relaxors have gained special interest in recent years because of their non-toxic nature, high dielectric permittivity, multiple phase transitions, tunable transition temperatures near room temperature, and broad frequency-dispersive permittivity peaks versus temperature. This study presents ferroelectric (FE) element/ site-specific spectroscopic investigations of the 30% Sn-doped $BaTiO_3$ ($BaTi_{0.7}{}^{119}Sn_{0.3}O_3$) relaxor ferroelectric using advanced ^{119}Sn hyperfine interaction techniques.

The structural and relaxor properties of the sample were studied through X-ray Diffraction (XRD), Raman Spectroscopy, Mössbauer Spectroscopy and temperature-dependent dielectric constant measurements. Synchrotron radiation perturbed angular correlation (SRPAC) experiments and temperature-dependent nuclear forward scattering (NFS) experiments were also conducted on the samples.

Temperature-dependent dielectric constant measurement confirms the relaxor behavior of the sample. SRPAC experiments provided direct evidence of quadrupole splitting (QS) below its dielectric maxima T_m, unambiguously identifying the presence of electric field gradients (EFGs) around Sn/Ti lattice sites. Additionally, temperature-dependent nuclear forward scattering (NFS) experiments corroborated the PAC results by clearly depicting the development of QS below T_m. Finite values of QS with temperature, below T_m, unambiguously indicate the development of EFGs around Sn/Ti sites in $BaTi_{0.7}{}^{119}Sn_{0.3}O_3$ relaxor. This results emphasis the applicability of conventional FE models in explaining relaxor properties. This study not only enhances the understanding of the local structural dynamics in $BaT_{i0.7}Sn_{0.3}O_3$ relaxors but also underscores the role of hyperfine interactions in elucidating the complex behavior of relaxor materials at a microscopic level. This study also highlights the importance of employing experimental methods that can offer complementary insights into the atomic-scale structural distortions , thereby contributing to a more reliable understanding of relaxor-type materials.

Identification of Different Local Coordination Geometries Around Cu Center Using XAFS in Mixed Ligand Copper Complexes

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X-ray absorption fine structure (XAFS) has been investigated at the Cu K-edge in copper complexes: $Cu(en)_2(ClO_4)_2$(**1**), $Cu(en)_2SO_4$(**2**), $[Cu(tmen)(bipy)](ClO_4)_2$(**3**), $[Cu(tmen)(en)](SO_4)\cdot 4H_2O$(**4**), $[Cu(tmen)(gly)](ClO_4)$(**5**), $[Cu(tmen)(phen)](ClO_4)_2$(**6**), where tmen=N,N,N′,N′-tetramethylethylenediamine, en=ethylenediamine, gly=glycinate ion, bpy= bipyridine, phen=phenanthroline, to probe the different local coordination geometry and electronic nature around Cu center.

The complexes have been prepared and characterized by the methods described in literature. The X-ray absorption spectra of the complexes have been recorded at the K-edge of copper on BL-9 scanning type EXAFS beamline at 2.5 GeV Indus-2 synchrotron X-ray source at RRCAT, Indore.

Crystal structure of **1** and **2** is known to be distorted octahedral and the same result has been obtained from EXAFS analysis. Structures of **3-6** are not available. From analysis of XANES and its derivative spectra, the structures of **3** and **4** have been estimated to be square pyramidal and of **5** and **6** to be square planar. EXAFS has been analyzed by two methods. In the first method, coordination number N has been varied and amplitude reduction factor S_0^2 has been fixed. In the second method, N has been fixed and S_0^2 has been varied. Thus, two complexes of each of the three different geometries have been subjected to two different methods of XAFS analysis and the results obtained by the two methods have been found to be nearly same. Ab-initio XANES calculations have been performed to obtain simulated XANES spectra as well as p-DOS and d-DOS for the absorbing Cu metal center. The XANES calculations reproduce well the absorption edge in the experimental XANES spectra. The splitting of Cu K-edge into two edges K_1 and K_2 has been correlated with the p-DOS. The occurrence of pre-edge has been correlated with d-DOS.

Exploring the Free Energy Landscape of a Structurally Homologous Protein using Temperature-Replica Exchange Molecular Dynamics (T-REMD)

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Homologous proteins have conserved secondary structural motifs despite having distinct amino acid sequences can have similar, different function roles. Our study aims to investigate whether homologous proteins exhibit similar or distinct free energy landscapes (FEL) and dynamics due to variations in their sequences. To investigate the sequence effect on the exploration of FEL of homologous protein at room temperature, we selected homologous of Acylphosphatase (AcP), a small enzyme of approximately 98 residues. AcP specifically cleaves the carboxyl-phosphate bond of metabolic intermediates and is found in both eukaryotic and prokaryotic organisms.

Homologous of AcP from 4 organisms—*Drosophila melanogaster, Bos taurus, Bacillus subtilis* and *Saccharolobus solfataricus* were chosen, exhibiting sequence similarity of 20-40%. Molecular dynamics simulations were performed using enhance sampling method T-REMD to explore larger conformational space with lesser computational cost. T-REMD utilizes replicas of the system at varying temperatures and by satisfying Metropolis criteria adjacent replicas gets exchanged, replicas have a random walk in temperature space. This approach helps the system escape from local energy minima, make possible to sampling a broader conformational landscape.

FEL analysis provides a detailed view on the conformational dynamics and stability of homologous proteins. Our findings demonstrate that the FEL of homologous proteins are not identical but instead exhibit distinct conformational landscapes, reflecting the presence of unique conformational states corresponds to different basins. These differences suggest that even subtle variations in protein sequences can lead to significant alterations in their dynamics. Moreover, differences in intramolecular contact maps and hydrogen bond fractions further highlight the impact of sequence diversity on protein stability.

Anomalous Transverse Electrical and Thermoelectric Effects in Amorphous CoFeB Thin Films

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The anomalous Nernst effect (ANE), the thermoelectric analogue of the anomalous Hall effect (AHE), arises from interaction of charge transport and a temperature gradient, providing unique insights into material properties. ANE has significant potential in energy-efficient spintronic devices as it offers superior heat management and can overcoming Wiedemann Franz law limitations. Amorphous CoFeB, a soft ferromagnetic material with high spin polarization and scalable fabrication, is widely used in spin-caloritronic applications. While its electrical transport is well-studied, thermoelectric properties remain unexplored. Our study on ~50 nm $Co_{60}Fe_{40}B_{20}$ films reveals intrinsic mechanisms dominating AHE and ANE, suggesting density of states (DOS) peaks near the Fermi level contribute significantly to transport.

CoFeB thin films were deposited on silicon substrates using direct current magnetron sputtering (dcMS) temperature. X-ray diffraction (XRD) using a Cu-Kα source (λ = 1.54184 Å) confirmed the films amorphous nature. Longitudinal resistivity (ρ_{xx}) and transverse resistivity (ρ_{xy}) were measured using a home-built switching system integrated into a 14T PPMS. Thermopower (S_{xx}) was measured via the heat pulse method, while ANE measurements as a function of temperature and magnetic field angles were performed in a closed-cycle helium refrigerator.

The growing energy demand in high-speed data storage devices necessitates energy-efficient solutions. Amorphous CoFeB, a soft ferromagnetic material with low magnetic damping, high saturation magnetization, and spin polarization, has gained attention for spintronic applications. ANE, a transverse thermoelectric phenomenon, emerges as a promising approach. However, ANE and its origin in amorphous CoFeB remains unexplored. By studying the temperature dependence of AHE and ANE, we have evaluated critical important parameters such as longitudinal and transverse electrical/thermoelectric conductivities and Hall/Nernst angles. Our findings reveal a significant intrinsic contribution, to the anomalous transverse effects, attributed to local Berry curvature. This intrinsic mechanism's contribution is crucial, as it underscores the potential for efficient energy harvesting in spintronic devices.

Cooperative Emission Phenomena in Lead Halide Perovskites Nanocrystals: Superfluorescence

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Superfluorescence (SF) is a cooperative optical phenomenon in which a large number of emitters interact through a light field and then spontaneously synchronize into the same phase and emit an intense and coherent burst of light. Previous studies have shown that SF is restricted up to cryogenic temperature even under strong magnetic field due to short dephasing time. Recently lead halide perovskites (LHPs) were found to exhibit room temperature SF, though it has been described within a polaron framework (non-interacting) despite strong interactions in LHPs. Our work demonstrates SF by condensing the electron-hole plasma (EHP) state into an electron-hole liquid (EHL) state at room temperature without any external stimuli in $CsPbBr_3$ nanocrystals.

Femtosecond photoluminescence (PL) and pump-probe spectroscopy were used to study SF and its key features, including quadratic dependence, coherence buildup time, decay time, and Burnham-Chiao ringing behavior. The variable stripe length method determined the dephasing time at room temperature. $CsPbBr_3$ nanocrystals were synthesized via a room-temperature method and drop-casted onto a microscope slide for measurements. Cs-OA and $PbBr_2$ stock solutions were dissolved in hexane, heated under vacuum, and mixed with lecithin. The nanocrystals were precipitated using acetone and centrifugation and then precipitate was redispersed in anhydrous hexane, centrifuged, and the supernatant collected. TEM and UV-Vis spectroscopy characterized the nanocrystals.

Our PL measurements show that beyond 850 $\mu J/cm^2$, a sharp and narrow peak emerges which is ~ 98 meV redshifted from the uncorrelated spontaneous emission. Key attributes heralding SF include a fluence-dependent delayed growth of macroscopic coherence with an abrupt radiative decay ~ 1250 times faster than spontaneous emission, a distinct quadratic fluence dependence with a clear threshold, and Burnham-Chiao ringing. Demonstrating SF at room temperature would mark a breakthrough for applications in quantum optics, lasers, and communication technologies.

Effect of Amphoteric Nature of Europium & Praseodymium Ions on Piezoelectric Response of NKBT: An Environmentally Friendly Promising Lead-free Piezoelectric

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The demand for lead-free piezoelectrics is growing due to concerns about lead toxicity. To overcome these challenges, researchers are investigating various solid-solutions and a range of dopants. A solid solution of sodium and potassium bismuth titanate (NBT-KBT) with morphotropic phase boundary in the range $0.16 \leq x \leq 0.20$ is promising. Of late, to improve its property various dopants are being explored. Rare earth (RE) doping is known to significantly improve the piezo-response in lead-based perovskites. In the present work, Europium (Eu^{+3}) and praseodymium (Pr^{+3}) doped 0.82NBT-0.18KBT is investigated for the piezoelectric and ferroelectric response.

RE doped NKBT with different doping concentrations (0.5, 1.0, 1.5, 2.0 & 3.0 at%) was synthesized by solid-state reaction method. The single-phase formation was confirmed by X-ray diffraction (XRD) whereas microstructure and composition analysis were evaluated by using scanning electron microscopy and Energy dispersive X-ray spectroscopy. The piezoelectric response was studied after poling the sintered ceramic samples. P-E hysteresis loop revealed the behaviour of remnant polarization and coercive field. XPS (Indus 2, Beam line 14, RRCAT) and conductivity measurements were carried out to verify the assertion of amphoteric nature of RE ions.

The piezoelectric response and remnant polarization were found to increase gradually till 1.0 at% doping of RE and thereafter it decreases sharply. The mechanism responsible for this behavior was investigated using X-ray photoelectron spectroscopy and electrical conductivity measurements. Based on these measurements, the optimum piezoelectric response near 1.0 at% of RE doping is attributed to the reduction in the concentration of oxygen defects for samples with lower doping and its increase for the samples with higher doping as observed in both measurements. The outcome further suggests that the amphoteric nature of RE in NKBT could be responsible for the observed unusual characteristic of the oxygen defect concentration in RE:NKBT. Further, single crystals of RE:NKBT were also grown and investigated for their piezoelectric properties.

Anomalous Absorption of High Power Microwave Pulse in a Plasma Filled Waveguide

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A high power short pulse microwave, propagating though a plasma filled waveguide, undergoes anomalous absorption through transferring ponderomotive energy to electrons. The electrons, under the ponderomotive force, move radially outwards from the axial region on the time scale of plasma period $2\pi / \omega_p$, taking away ponderomotive energy from the pulse. Part of that energy is stored in the space charge field of the ion channel thus created. The fractional energy loss of the pulse is strong when pulse duration is of the order of plasma period, electron quiver velocity is high fraction of speed of light and plasma density is high as observed experimentally by Cao et al.[16] (Phys. Plas. **28**, 062307 (2021)).

First Constraints on the Redshifted 21 cm Signal at z~9 from uGMRT Band-2 Observations in the ELAIS-N1 Field

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The detection of the redshifted 21 cm signal from neutral hydrogen provides a unique window into the early Universe, spanning the Cosmic Dawn (CD) and the Epoch of Reionization (EoR). However, this faint signal is obscured by 4-5 order magnitude higher bright foreground from Galactic synchrotron radiation and extragalactic radio sources, posing a significant challenge for its detection. Understanding and mitigating these foregrounds is crucial for isolating the cosmological signal.

In this work, we present deep observations of the ELAIS-N1 field at Band-2 (120–250 MHz) using the upgraded Giant Meterwave Radio Telescope (uGMRT), a key pathfinder for the Square Kilometre Array (SKA). We processed 16 hours of wideband data using direction-dependent calibration technique and imaging to proceed with foreground mitigation, and statistical analysis techniques to place stringent upper limits on the 21 cm power spectrum at redshift z~9. Special attention is given to systematic effects such as ionospheric distortions, radio frequency interference (RFI), and instrumental noise.

Our first results contribute to ongoing efforts in 21 cm signal using Indian radio telescope, providing valuable constraints on the reionization process and the physical conditions of the large scale structure. The method and techniques demonstrated in this work pave the way for future high-sensitivity experiments with next-generation low-frequency radio arrays, bringing us closer to detecting the elusive 21 cm signal.

Structural and Electrical Properties of Co-doped ZnO Nanoparticles Synthesized Via Thermal Decomposition Method

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In the current study, impact on structural, and electrical properties of $Zn_{1-x}Co_xO$, x=0.0, 0.01, 0.03 and 0.05 nanoparticles (NPs) were investigated. $Zn_{1-x}Co_xO$, x=0.0, 0.01, 0.03 and 0.05 were synthesized by the thermal decomposition technique. XRD confirmed $Zn_{1-x}Co_xO$ good incorporation of dopant ions in the ZnO lattice. Field emission scanning electron microscopy (FESEM) confirmed the surface morphology of prepared ZnO NPs. Energy dispersive X-ray spectroscopy (EDS) provided the compositional information of prepared NPs having concentrations of Zn, Co, and O in the prepared NPs. Dielectric constant decreases with x, while the ac electrical conductivity increases with applied frequency. Recently, doped ZnO NPs have been used for the preparation of dyes, which are used for the formation of highly efficient dye sensitized solar cells (DSSC).

Stoichiometric amounts of zinc acetate dihydrate $Zn(CH_3CO_2)_2.2(H_2O)_2$ and cobalt (II) acetate tetrahydrate $Co(CH_3CO_2)_2.4H_2O$ were put in a beaker containing 15 ml of ethylene glycol $HOCH_2CH_2HO$. After this, they were mixed together by stirring it for 15 min using a magnetic stirrer. Then, the mixture was heated for 10 min at 80 ºC until a viscous gel was formed. Then, the resultant solution was calcined in a cylindrical crucible at 500 ºC for 3 hours to dry the sample. The resultant sample was ground for 1 hour using an agate mortar and pestle to get the sample in powder form. Similar steps were repeated for synthesizing $Zn_{1-x}Co_xO$, x=0.0, 0.01, 0.03 and 0.05 NPs.

In present study, $Zn_{1-x}Co_xO$, x=0.0, 0.01, 0.03 and 0.05 were prepared by the thermal decomposition scheme. They were characterized by several characterization techniques. XRD study indicates their hexagonal wurtzite type structure. The FESEM images show that they have spherical shape. EDX revealed a sharp Zn, Co and O peak intensity with different concentrations of Co. Furthermore, there is a reduction in value of the dielectric constant while increasing x in the structure. An increase in ac electrical conductivity was due to an increase in charge density at higher frequencies. The results of this study lend credence to the idea of creating low-cost anodes that may be utilized to make dye-sensitized solar cells.

Unveiling the Structural, Mechanical, Electronic, Magnetic and Transport properties of novel $CeMO_3$ (M= Ag, W) via DFT calculations

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The current research employed first-principles calculations to investigate the physical characteristics of $CeAgO_3$ and $CeWO_3$ perovskite compounds. This was achieved using the FP-LAPW method based on Density Functional Theory (DFT), as implemented in the WIEN2k software. The study analysed the electronic and transport properties of perovskite materials using the TB-mBJ functional, focusing on their structural properties through the GGA-PBE approximation. The mechanical stability has been confirmed through analysis of elastic parameters. Next, our study delved into the electronic and magnetic properties of the perovskites $CeWO_3$ and $CeAgO_3$ using two distinct approximation methods: GGA and mBJ. Through an analysis of the density of states and band structures, we observed that these oxide perovskites display metallic behaviour. Furthermore, our investigation into the magnetic properties of $CeWO_3$ and $CeAgO_3$ revealed that both these perovskites exhibit a significant magnetic moment. The Boltzmann transport code integrated with the WIEN2k software was employed to calculate the thermoelectric properties of the studied compounds. Based on the calculations, it is evident that these alloys demonstrate an excellent power factor, indicating significant potential for thermoelectric applications.

Magnetoelectric Coupling Measurement: Development of a Setup and Case Study on 0.67$BiFeO_3$-0.33$BaTiO_3$ (BF-33BT) Multiferroic

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Multiferroics have garnered significant attention due to their potential for applications in devices such as sensors, actuators etc. Understanding the physics behind the coupling between magnetic and electric order parameters is crucial for realizing these applications. The magnetoelectric (ME) coupling is a fascinating phenomenon offered by multiferroic compounds where electric and magnetic properties intertwine. It's characterized as the magnetoelectric coupling coefficient (α_{ME}), which quantifies the change in the induced electric field (E) in response to an applied magnetic field (H) [1].

$$\alpha_{ME} = \frac{dE}{dH_{DC}}$$

The values of α_{ME} are usually very small of the orders of ~μV to mV/mm.Oe. Precise measurements of such effects/signals are a challenge. We report here development of a versatile setup for α_{ME} measurements adopting the dynamic method [2]. This setup accommodates both pallet and thin-film samples. DC and AC magnetic fields are applied using an electromagnet and a lock-in amplifier (LIA), respectively. The LIA also measures the induced voltage across the sample. Python-based automation enables α_{ME} measurements as a function of magnetic field and frequency.

Performance of the setup is tested on a standard compound PMN-PT. Subsequently, a morphotropic phase boundary (MPB) solid solution of $BiFeO_3$ & $BaTiO_3$ i.e., 0.67$BiFeO_3$-0.33$BaTiO_3$ (BF-33BT) [3] is studied using this setup. The magnetoelectric coupling properties of BF-33BT were investigated as a function of frequency and magnitude of the AC magnetic field at different DC field values. A minimum AC field value (~ 10 Oe) was determined, below which reliable measurements could not be obtained. Resonance frequencies associated with the magnetoelectric phenomena in the compound were also identified. The α_{ME} measurements showed a linear increase with increasing magnetic field up to 5 kOe. The value of α_{ME} at 5 kOe DC field (@ 23 Hz) is ~ 34 μV/mm.Oe.

Large Magnetocaloric Effect and Large Thermal Expansion near Room Temperature in Ni-Co-Mn-Ti alloys

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Refrigeration technology based on caloric effects in solids, such as magnetocaloric effect, offers an environment friendly alternative to traditional vapour-compression based cooling by having zero greenhouse-gas emission. It is generally observed that materials which undergo a first order magneto-structural transition show significant caloric effects accompanied by a large thermal expansion. The objective of this work is to explore new earth-abundant materials which show multifunctional properties for technological applications such as magnetic refrigeration and actuators.

$Ni_{37}Co_{13}Mn_{34}Ti_{16}$ and $Ni_{37}Co_{13}Mn_{34.5}Ti_{15.5}$ alloys were synthesized using arc-melting method. The microstructure was observed using optical metallography and scanning electron microscopy. The composition was determined by energy dispersive spectroscopy. Magnetic properties were studied using temperature dependent ac susceptibility and magnetization measurements. Thermal expansion was measured using the strain gauge technique.

Magnetization, ac susceptibility and thermal expansion measurements indicate the presence of a first order magneto-structural transition near room temperature in the alloys under consideration. Large entropy changes of nearly 8.6 $Jkg^{-1}K^{-1}$ and 13.6 $Jkg^{-1}K^{-1}$ were observed across this transition for a magnetic field excursion of 7 T in $Ni_{37}Co_{13}Mn_{34}Ti_{16}$ and $Ni_{37}Co_{13}Mn_{34.5}Ti_{15.5}$ alloys respectively. In addition to the entropy change, large thermal expansions of about 0.5% and 0.35% were also observed in these alloys respectively across the magneto-structural transition. The observed entropy change is comparable to that seen in Gd and Gd-based rare-earth alloys which are commonly used in existing proof-of-concept prototype magnetic refrigerators. The thermal expansion observed in these alloys is comparable to the magnetostriction observed in a rare-earth intermetallic alloy Terfenol-D, which is a commonly used material for actuator applications, Our findings suggest that the Ni-Co-Mn-Ti alloy system offers great promise for environment friendly magnetic refrigeration and actuator applications based on commercially viable earth-abundant elements.

Three Distinct Boolean States for Terahertz Based High-Speed Communication

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The demand for higher data transmission rates is escalating due to growing user base and rapid technological advancement. Upcoming 6^{th} generation of communication technology is anticipated to utilize terahertz radiation, which offers access to significantly larger bandwidth. Therefore, developing efficient mechanisms for high-capacity data transmission in the terahertz frequency regime has potential to transform the communication sector.

To develop suitable materials for the stated purpose, coherent epitaxial heterostructures of rare-earth nickelate ($NdNiO_3$) were synthesized using the pulsed laser deposition technique. Capability to manipulate terahertz radiation was assessed by examining their optical parameters through steady-state and time-resolved terahertz spectroscopic techniques, positioning this study as a unique integration of material synthesis and advanced optical characterizations.

In this study, we have demonstrated the non-equilibrium dynamics of compressively and tensile strained $NdNiO_3$ epitaxial heterostructures by employing optical pump THz probe spectroscopy. Fluence-dependent negative photoconductivity, in addition to, first-time direct evidence of azimuthal angle-dependent switching of THz negative-positive photoconductivity at room temperature has been reported. Moreover, we established oxygen vacancies as the key factor responsible for room-temperature anisotropic THz photoconductivity through complimentary steady state THz spectroscopy and by analyzing samples with different levels of oxygen vacancies. The unique negative-positive photoconductivity switching feature can be beneficial in constructing a three state THz communication system for which we have demonstrated a “proof of concept” device, which utilizes both signs of THz photoconductivity to develop the proposed three state THz communication system.

High-resolution Spectroscopy of a Single Nitrogen-vacancy Defect at Zero Magnetic Field

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The objective of this work was to measure the intrinsic effective field (electric field and strain) of a diamond using single nitrogen-vacancy (NV) centers in diamond. Nitrogen-vacancy (NV) center, a paramagnetic defect in diamond, is a highly versatile sensor with excellent sensitivity to magnetic, electric, and stress fields at room temperature. Owing to the well-established optical initialization and readout methods, the ground state spin of the NV center is amenable to sensing applications. The quantum sensing properties of the NV centers are being exploited for applications in biology, geology, material science, condensed matter physics, quantum computation, and information processing. However, the intrinsic local strain and charge environments can interfere with zero-field sensing applications. This work explores the influence of these intrinsic fields on hyperfine level structures using pulsed electron spin resonance spectroscopy.

A type IIa- polycrystalline diamond and a type-Ib single crystal diamond sample was used in this study. The experiments used a custom-built confocal microscopy setup for addressing single NV centers at room temperature. A 532 nm laser provided excitation, and red fluorescence was collected for analysis. Microwave fields were applied using two 20 microns wires spanned across the diamond in a cross configuration, and stray magnetic fields were minimized using permanent magnets. High-resolution spectra were obtained by sweeping the microwave frequency across NV spin transitions, while suppressing power broadening. Spectroscopic data were analyzed to extract effective field parameters using theoretical modeling.

The study reveals that intrinsic strain fields dominate the zero-field spectral features in NV centers, leading to hyperfine splitting, shifting and transition imbalances. A significant finding is the mixing of outer hyperfine transitions due to strong effective fields in polycrystalline diamond (PCD) samples, observed experimentally for the first time. The theoretical model developed by us supports these observations, providing insights into the polarization-selective microwave response of hyperfine transitions. Moreover, we also characterize the effective field environment surrounding NV spins in different regions of the PCD sample. This work opens avenues for enhanced zero-field sensing, precise strain imaging, and understanding NV-based quantum sensing mechanisms. The findings are instrumental for applications in quantum computation, information processing, and nanoscale measurements.

Growth and Electrical Characterization of Superconducting Thin Films for Superconducting Nanowire Single Photon Detector Applications

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Superconducting Nanowire Single Photon Detectors (SNSPDs) are highly sensitive devices crucial for quantum technologies such as quantum communications and cryptography. They operate through the superconducting transition in thin films, where photon absorption induces a localized resistive state, generating a detectable voltage pulse. The performance of SNSPDs is strongly influenced by the superconducting material properties, which depend on factors like film composition, microstructure, and deposition conditions. Understanding and optimizing these factors are essential for advancing high-performance detectors.

In the present study, we investigated the superconducting properties of amorphous Mo_xSi_{100-x} (x=80,83) and polycrystalline $Ti_{40}V_{60}$ thin films, focusing on their superconducting critical temperature (T_C) and critical current density (J_C). The films were fabricated using DC magnetron sputtering under varying deposition pressures, which were systematically controlled to study their influence on material performance. Structural characterization was done using X-ray diffraction (XRD) to assess the film crystallinity and phase purity, while transport measurements and current-voltage (I-V) characteristics provided insights into their superconducting behavior and critical parameters.

Our observations indicates that $Mo_{80}Si_{20}$ films exhibited a higher T_C compared to $Mo_{83}Si_{17}$, attributed to differences in stoichiometry and deposition conditions. Additionally, $Ti_{40}V_{60}$ films demonstrated superior J_C, making them suitable for applications requiring high current handling for improved efficiency of the detector. Varying deposition pressure was found to significantly tune the superconducting properties of both material systems, enabling the identification of optimal conditions for performance enhancement. These results underline the potential of Mo_xSi_{100-x} and $Ti_{40}V_{60}$ thin films as promising candidates for SNSPDs and superconducting radiation detectors. The findings contribute valuable insights into material design and process optimization, with implications for photon detection in different wavelengths, as well as broader quantum technology applications.

Covalency Driven Metal-insulator Behavior of Barium Lead Oxides

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$BaPbO_3$(BPO) and Ba_2PbO_4(B2PO) are closely related compounds, sharing an identical valence configuration. Despite their structural similarities, they exhibit contrasting electronic properties: BPO is reported to be metallic, while B2PO is a gapped semiconductor. However, the metallic nature of BPO remains a topic of debate, with conflicting interpretations in the literature. Previous study combining experimental and theoretical approaches suggested that octahedral rotations are responsible for the metallic behavior of BPO. Conversely, a recent theoretical investigation linked octahedral distortions to a gapped behavior. Motivated by these conflicting conclusions, we investigate the electronic structure of BPO and B2PO using density functional theory (DFT). Our findings reveal that B2PO has a larger semiconducting band gap of 1.4 eV compared to BPO, even in the absence of octahedral distortions. Using maximally localized Wannier function (MLWF) calculations, we uncover that the key to the band gap opening lies in the reduction of Pb-O covalency in these systems. In contrast, the confinement of Pb-O covalency to two-dimensional PbO_2 layers in B2PO results in its semiconducting nature.

QCD Axions Conversion in the Magnetospheres of Neutron Stars

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The axion-converted-photons flux is a principal window for the QCD axions as a dark matter (DM) candidate. In addition to solving the strong CP problem, these may explain the properties of the mysterious DM. Neutron star (NS) cooling by neutrino/axion emissions rate constrain the astrophysical properties of superdense matter.

We study the impact of magnetic fields on the emission properties of NS. We employ FPS EoS to generate profiles from the TOV equations. We assume Cooper-pair-breaking formation (PBF) and the Bremsstrahlung process in the NS core. We also calculate the energy spectrum of axions and their conversion to photons.

We present the results for spherically symmetric magnetized NSs, assuming the core comprises hadronic matter. We use the distance-dependent magnetic field configuration and TOV equations in the presence of magnetic fields. We analyse the effect of the magnetic field by considering the upper limit for the central magnetic field. Our results show that the cooling rate and the luminosity of observables (axions) for NSs changes significantly due to the intense magnetic field. The spectrum of axions from the Bremsstrahlung process dominates over the PBF process at lesser values of axion energies within the possible axion mass range. The impact of the magnetic field is less at lower axion energies, which indicates the necessity for inclusion of a magnetic field in axion-to-photon conversion mechanisms. After incorporating magnetic field effects on the various possible NS cooling mechanisms and equations of states, one can develop an improved understanding of the NSs physics and axionic DM properties. In the future, these advancements will coincide with new directions in theoretical research and observational techniques.

Negative Temperature Coefficient of Resistivity in Metallic $V_{0.3}Ti_{0.7}$ Alloy Due to Spin Fluctuations

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Our previous work on the $V_{0.6}Ti_{0.4}$-Gd alloys showed that Gd, despite being insoluble in the matrix and precipitating along the grain boundaries, induces (a) long-range ferromagnetic order (LRFO), (b) marginal enhancement in superconducting transition temperature (T_C), and (c) lowering of electrical resistivity. To explain this, it was hypothesized that conduction electrons near grain boundaries get polarised, which leads to suppression of spin fluctuations (SF) in V-Ti matrix. Additionally, it has been reported that SF can lead to negative temperature coefficient of resistivity (TCR) in disordered metallic alloys. Given that SF are intrinsic to the V-Ti alloys, with $V_{0.3}Ti_{0.7}$ showing a negative TCR, it is compelling to compare the temperature dependence of electrical resistivity of $V_{0.3}Ti_{0.7}$ and $V_{0.3}Ti_{0.7}$-Gd.

Polycrystalline $V_{0.3-x}Gd_xTi_{0.7}$ and $V_{0.3-y}La_yTi_{0.7}$ samples used in this study were synthesized by arc melting. Electrical resistivity and Hall effect measurements were performed using a PPMS (QD, USA). *DC* magnetization was measured with a Superconducting Quantum Interference Device Vibrating Sample Magnetometer (MPMS-3 VSM, QD, USA).

Saturation in field dependence of magnetisation and anomalous Hall effect is observed in $V_{0.3-x}Gd_xTi_{0.7}$ alloys for $x \geq 0.02$. These indicate a LRFO and polarisation of V-Ti conduction electrons in the bulk of sample. Interestingly, negative TCR in $V_{0.3}Ti_{0.7}$ gradually changes to positive with Gd addition when $x \geq 0.02$, while no such change is observed when La (non-magnetic) is added. Ferromagnetism due to Gd addition suppresses the SF and restores positive TCR, suggesting that SF are the underlying cause of negative TCR in $V_{0.3}Ti_{0.7}$. Additional evidence of suppression of SF due to Gd addition in $V_{0.3}Ti_{0.7}$ is found in form of enhanced T_C and reduction of normal to superconducting transition width. This study provide insights into the role of magnetic precipitates embedded in a non-magnetic matrix on the superconducting and magnetic properties.

Symmetry-Controlled Spin-Splitting in Orthorhombic Altermagnets

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Altermagnetism has recently emerged as a promising magnetic phase for technology. This phase shows non-degenerate bands from opposite spin sublattices despite vanishing net magnetization. In this study, we use density functional theory (DFT) to investigate the electronic and magnetic properties of two centrosymmetric materials: bulk orthorhombic $BiFeO_3$ (BFO) and $CaMnO_3$ (CMO), both belonging to non-symmorphic *Pnma* space group. Our non-relativistic calculations reveal that the lowest-energy G-type antiferromagnetic phase shows substantial spin-splitting only in $k_x = 0$ plane due to the absence of time-reversal (*T*) symmetry. Our calculations reveal weak ferromagnetism upon considering spin-orbit interaction (SOI).

First-principles calculations were performed within DFT. The exchange-correlation function is treated within the generalized gradient approximation (GGA) with Hubbard-U correction. The computed indirect band gaps are 1.91 eV and 1.23 eV, with projected magnetic moments of 4.16 μ_B and 2.74 μ_B for BFO and CMO, respectively. These compounds break the combined inversion| time reversal (*PT*) and combined spin rotation| translation (*Ut*) symmetries that results in the non-degenerate bands along $\bar{T}$- Γ-T high symmetry path for both compounds. Spin quantization energy calculations indicate that the [001] axis is the preferred easy axis for both materials. Upon including SOI, a weak ferromagnetic moment of 0.036 μ_B (BFO) and 0.287 μ_B (CMO) emerges along the [010] direction, leading to a nonzero anomalous Hall conductivity (AHC).

Our results confirm the altermagnetism in both BFO and CMO with a notable spin-splitting within the lowest energy antiferromagnetic configuration in $k_x = 0$ plane, while maintaining the degeneracy in other planes for both the compounds. When spin-orbit coupling is included, a weak ferromagnetic component along [010] direction emerges, leading to a nonzero anomalous Hall conductivity. Our work paves the way for BFO and CMO as an alter magnetic candidate to be used for spintronic applications.

Influence of Shell Architecture on Dielectric Loss Suppression and Relaxation Dynamics of PVDF/$BaTiO_3$@Al_2O_3 Nanocomposites for Advanced Capacitor and Energy Storage Applications

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Core-shell nanostructures exhibit superior multifunctional properties, making them pivotal for energy storage applications. This study aims to engineer advanced polymer nanocomposites with optimized dielectric performance. A comprehensive analysis of structural integrity, interfacial interactions, and synthesis methodologies is imperative for enhancing their efficiency in next-generation capacitors and high-performance electronic systems.

As purchased PVDF, $BaTiO_3$ and hydrothermally prepared $BaTiO_3$, $BaTiO_3$@Al_2O_3 prepared via heterogeneous nucleation method were used to synthesize PNC by varying the weight percentage of $BaTiO_3$@Al_2O_3 into the PVDF matrix through the novel cold pressing method. The structure, microstructure, thermal, and the electrical properties of the samples were characterized by using XRD, FESEM, TEM, DSC/TGA, ferroelectric P-E loop tracer, and LCR meter.

The $BaTiO_3$@Al_2O_3 core-shell structure was confirmed from the TEM micrograph and exhibited a high static ε_{eff} of 2450 with an exceptionally low Tan δ ~0.1, attributed to the thick insulating Al_2O_3 shell suppressing dipolar relaxation. Additionally, a higher dielectric field strength (≥20 kV/cm) was observed in $BaTiO_3$@Al_2O_3 through P-E loops. To further explore its potential for dielectric applications, cold-pressed PVDF/$BaTiO_3$@Al_2O_3 PNCs were synthesized. The cold-pressing technique preserved PVDF spherulites and enhanced ε_{eff}. Modified HN equation well satisfies with an increase in filler concentration indicating the enhancement of degree of polarization leads to an increase in the value of the asymmetric broadening parameter. Yamada model was well fitted with dielectric data, explaining the sum properties of PNCs. Moreover, the insulating Al_2O_3 shell effectively suppressed Tan δ, achieving a remarkably low value (~0.2) at 60 wt% $BaTiO_3$@Al_2O_3 loading. The AC conductivity followed Jonscher's power law, while modulus spectra fitted with modified KWW function exhibited broad, non-Debye-type relaxations with stretching coefficients (β) ranging from 0.3 to 0.41. These results highlight the promising potential of PVDF/$BaTiO_3$@Al_2O_3 PNCs as high-performance dielectric materials for next-generation capacitors and advanced energy storage applications.

Performance Analysis of a Flexible Electrochemical Double-layer Capacitor

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The present work analyzes the performance parameter of a flexible electrochemical double-layer capacitor (EDLC) developed using a solid polymer composite electrolyte based on PEO+$LiCF_3SO_3$ (O/Li ~ 15) +Ti-LLZO (20wt%). The device provides a specific capacitance (C_{spc}) of 7.86 mF/g at a 10mV scan rate at normal conditions (180^0). To understand its structural flexibility, the entire device has been bent at 150° and 120°. The device's specific capacitance (C_{spc}) at these bend positions has slightly reduced to 7.501 mF/g and 6.950 mF/g at 150° and 120°. The overall performance of the flexible device is almost steady in longer cycles in different bending positions, indicating it is a promising device for flexible energy storage.

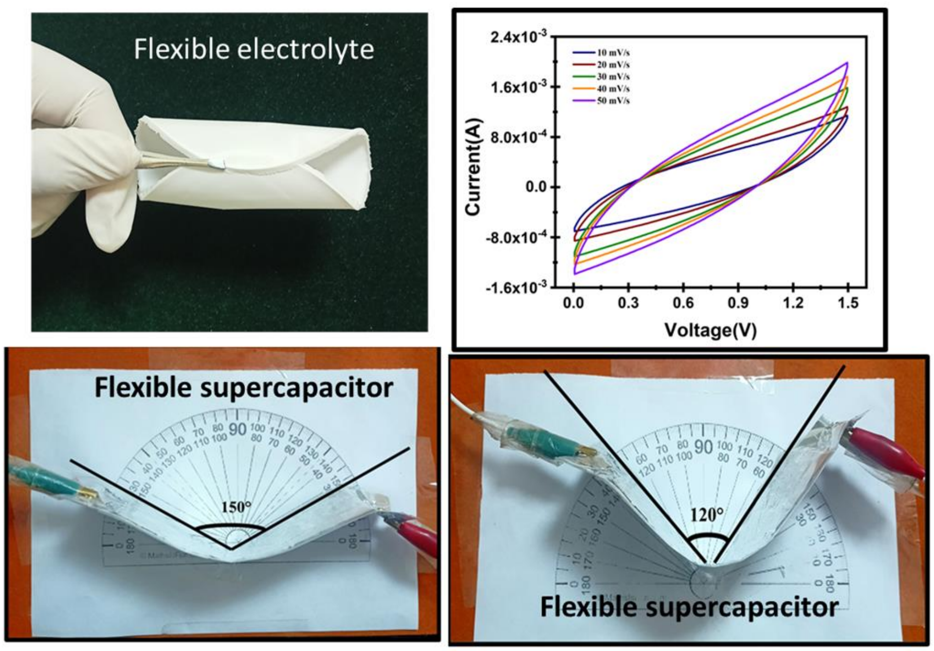

Figure 1. (a) Flexible electrolyte (b) CV of flexible EDLC device. EDLC device (c) bend deviation 150° and (d) 120°.

Rabi Oscillations in Stimulated Two-photon Raman Transition in a Cold ^{87}Rb Atom

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Cold atom interferometry utilizing stimulated two-photon Raman transitions enables precise and highly accurate measurements of local gravitational acceleration (g). This technique employs a sequence of Raman pulses ($\pi/2$ - π - $\pi/2$) to coherently split, invert, and recombine atomic wave packets. The durations of the $\pi/2$ and π pulses are determined by analyzing Rabi oscillations in the ***population*** of the hyperfine ground state (5 $^2S_{1/2}$, F = 1 or 2) of a ^{87}Rb atom. Experimentally, Rabi oscillations in the population of F = 2 hyperfine state of the ^{87}Rb atom exhibit damping, attributed to various decoherence mechanisms.

A four-level atomic system, modeled using the density matrix formalism, is employed to study the damping of Rabi **oscillations** in the **population** of the hyperfine ground state (5 $^2S_{1/2}$, F = 1 or F = 2) of the ^{87}Rb atom due to stimulated two-photon Raman transitions. The scheme comprises two Λ-systems enabling two-photon Raman transitions via intermediate states (5 $^2P_{3/2}$, F' = 1 and F' = 2). The Lindblad master equation, incorporating decoherence effects, is solved to simulate the population dynamics using ^{87}Rb-specific parameters.

This theoretical model provides insights into the experimentally observed damping of Rabi oscillations in the hyperfine ground states of the ^{87}Rb atom. The damping primarily arises from two mechanisms: population decay due to spontaneous emission from the excited states and dephasing between pair of states caused by various factors. Dephasing in atomic systems can result from influences such as the Gaussian distribution of the atomic cloud, Doppler broadening in the atomic ensemble, the Gaussian profile of the interacting laser beam, fluctuations in laser frequency and intensity, and magnetic field gradients. Notably, dephasing between state pairs plays a more significant role in damping Rabi oscillations than spontaneous emission from the excited states.

Development of In-silico Based Intron Length Polymorphism (ILP) Marker and Their Application in Screening of Drought Tolerance and Mapping in Pea (Pisum sativum)

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Pea (*Pisum sativum L.*), an essential legume crop in the Fabaceae family, is globally recognized for its agricultural and nutritional value. Genetic improvement of this crop requires efficient molecular tools to explore and utilize its genetic diversity. This study aimed to develop and validate Intron Length Polymorphism (ILP) molecular markers using in-silico techniques. These markers are crucial for genetic analysis, diversity studies, and breeding programs, with potential applications in enhancing the resilience of pea cultivars to environmental stresses.

Seventeen pea accessions were carefully selected and cultivated under controlled and net house conditions. Using *in-silico* approaches, 816 ILP primers were designed and subjected to BLAST analysis to identify markers with significant matches. These markers were categorized into three functional groups: cellular function (41%), biological function (35.5%), and metabolic function (23%). A total of 162 ILP markers were mapped across the seven pea chromosomes, with the largest chromosome (chromosome 5, 652.92 Mb) harboring the highest number of markers (40) and an average marker spacing of 16.32 Mb. For further analysis, ten ILP primers were randomly selected, and their ability to detect polymorphisms was evaluated.

Eight of the ten selected ILP primers revealed polymorphisms, amplifying 25 alleles in total, 14 of which were polymorphic. The Polymorphism Information Content (PIC) values ranged from 0.07 to 0.8, demonstrating their utility in assessing genetic diversity. Notably, the ILP marker ARG5 amplified the highest number of alleles, while ARG34 showed the least. This study highlights the effectiveness of ILP markers as valuable tools for genetic analysis and breeding programs in pea and other legumes. The findings pave the way for future research aimed at enhancing crop resilience and improving genetic diversity, underscoring the broader significance of these markers in agricultural biotechnology.

When Taxonomy Meets Chemistry: Investigating the Potential of Floral Fragrances as a Taxonomic Tool in the Ginger Genus *Hedychium* (Zingiberaceae)

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Flowers communicate with insects using fragrances, resulting in a unique language that may be species-specific. This specificity in floral fragrances may therefore serve as its taxonomic identity. The present study aims to understand the fine-scale variations in the floral fragrance compositions of the closely related species within the ginger genus *Hedychium* (ginger-lilies) which is endemic to tropical Asia. Ginger-lilies were chosen to study the chemotaxonomic potential of fragrances because of the presence of species and their intermediates that cannot be morphologically distinguished and form species complexes.

A total of 22 species and two intermediate forms from two species complexes were sampled from the wild populations of Northeast India and Western Ghats as well as from the Queen Sirikit Botanic Garden in Northern Thailand during two peak flowering seasons. The floral fragrances were non-invasively extracted via dynamic headspace sampling in the field and analyzed using Gas chromatography-Mass spectrometry (GC-MS) at the parent institution (IISER Bhopal). The qualitative data were further subjected to multivariate analysis in R programming language.

Floral fragrance analyses revealed low chemical similarity between closely related species, each emitting distinct fragrance profiles despite sharing major compounds. This species-specific uniqueness confirms the taxonomic value of fragrance molecules. In species complexes, intermediate forms showed overlapping chemical signatures with their putative parental species, corroborating morphological and ecological data. Thus, chemical data is crucial for defining taxonomic boundaries, complementing other information for accurate identification. This study also allows us to explore the utility of fragrance profiles of such understudied plants in perfumery and cosmetic industries.

Optimizing Stevioside Production and Economic Viability in *Stevia rebaudiana* Bertoni: An Integrated Agroforestry Approach with Improved Plant Density and Organic Manures

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Stevia rebaudiana, a perennial herb prized for its steviol glycosides, is increasingly being cultivated as a natural sweetener. In India, the annual demand for this herb is estimated to approx. 10 MT. However, the relationship between harvest timing, agronomic practices and agroforestry systems on leaf yield, stevioside content and economic viability in tropical climates remains underexplored. This study evaluated the effects of harvest intervals (3rd, 4th, and 5th months post-sowing) and organic amendments on growth, productivity and stevioside dynamics in a teak-based agroforestry system in Central India.

A field experiment was conducted in a Randomized Block Design with a factorial concept under a teak-based agroforestry model at the NWFP nursery, ICFRE-TFRI, Jabalpur, Madhya Pradesh. The treatments included plant spacing (S1:45×45 cm; S2:30×30 cm; S3:20×20 cm) and organic nutrient regimes (M7-Farmyard Manure + vermicompost + poultry manure; M6-VC + PM; M5-FYM + PM; M4-FYM + VC; M3-PM; M2-FYM; M1-VC; M0-Control). Growth parameters (plant height, branch number and leaf count), biomass yield (fresh and dry weight) and stevioside content were quantified at monthly intervals using HPTLC technique. Economic viability was assessed via input-output ratios.

The results indicated enhanced plant height, branches and leaf count plant^{-1} under M7. Spacing S3 yielded maximum fresh and dry biomass, while M7 optimized stevioside content (peak: March, pre-flowering) which declined post-bud formation. Economic analysis revealed that S3 and M7 are cost-effective with higher net returns. These findings underscore that integrating teak agroforestry with earlier harvesting before on set of flowering and organic amendments enhances both yield and stevioside retention, offering a sustainable model for tropical stevia cultivation. This study provides actionable insights into optimizing harvest schedules and agronomic practices to balance productivity, metabolite quality and profitability in resource-constrained systems.

Evaluation of *Aegle Marmelos* (L.) Correa (Bael) Gene Pool of Madhya Pradesh

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The present study in Bael, entitled "Evaluation of *Aegle marmelos* (L.) Correa (Bael) Gene Pool of Madhya Pradesh" aims to identify the "Elite types" for future use and propagation in addition to evaluate the variability in different physical traits of fruits. The present study was carried out in Madhya Pradesh, India. 150 different accessions of bael fruit were collected from Chitrakoot, Khandwa and Narsinghpur for investigation.

The observations were recorded and analyzed using standard protocol. The diameter of the fruits and seeds was measured in milimeter with the help of Vernier calliper. The weight of fruits and seeds was taken with the help of electronic weighing machine and average weight of fruits and seeds was calculated. The thickness of skull was measured with the help of Vernier calliper in mm. The pulp weight of fruit was recorded after the pulp extraction and average pulp weight was calculated in gram. Total soluble solids (TSS) was measured by using refractrometer in °Brix (°Bx). Number of seeds per fruit was counted.

It is possible to deduce from the findings of this study that all of the bael accessions showed significant variations in their morphological characteristics. In accordance with the fruit's quantitative characteristics, the best accessions were recorded from location-2 i.e., Khandwa with fruit weight (472.38 m), skull thickness (6.0 mm), pulp weight (62.7 g), TSS (32.6 °Bx), seed weight (19.9 g), diameter of seed (5.9 mm) and number of seeds per fruit (26.9), which could be potentially include for further utilization and multiplication of quality planting material.

Genome of the Most Noxious Weed Water Hyacinth (*Eichhornia crassipes*) Provides Insights into Plant Invasiveness and its Translational Potential

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Eichhornia crassipes (water hyacinth) is a notorious weed known for its rapid invasion across the globe and is also listed in the Global Invasive Species Database. It is a major contributor to the loss of biodiversity and global food security. Also, recently water hyacinth has valorized from being notorious to a wonder plant with wide translation applications. However, genomic insights responsible for its invasiveness and translational potential were missing due to the unavailability of the genome sequence.

To investigate the genomic basis of invasiveness, we performed the genome sequencing of *E. crassipes* and reported the first "reference" quality genome using a hybrid assembly approach along with the transcriptome from the root, leaf, and stolon tissues. Further, by employing comprehensive comparative evolutionary analysis with other aquatic invasive and non-invasive angiosperm species, we identified key adaptive signatures in water hyacinth responsible for their invasive and translation potential.

The assembled genome had a size of 1.12 Gbp with 63,299 coding genes and N50 of 1.98 Mb. We confirmed a recent whole genome duplication event in *E. crassipes* that resulted in high intraspecific collinearity and significant expansion in gene families. Further, the orthologs gene clustering analysis and comparative evolutionary analysis with 14 other aquatic invasive and non-invasive angiosperm species revealed adaptive evolution in genes associated with plant-pathogen interaction, hormone signaling, abiotic stress tolerance, heavy metals sequestration, photosynthesis, and cell wall biosynthesis with highly expanded gene families, which contributes toward invasive characteristics of the water hyacinth. However, these characteristics also make water hyacinth an excellent candidate for biofuel production, phytoremediation, and other translational applications.

Physiological and Molecular Responses of Chickpea after Nano-priming with Molybdenum Nanoparticles

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Present day yield potential of chickpea in Madhya Pradesh is up to 6.0 tonnes/hectare, but average yield is stagnating at 1-1.5 tonnes/hectare. This wide gap between average and potential yield is due to various stresses that hamper chickpea production. Madhya Pradesh soils are poor in micronutrients like molybdenum. Despite molybdenum abundance, alkaline pH of soil prevents its absorption by plants. To combat these limitations, seed priming can be a method of choice. Nano-priming by molybdenum nanoparticles can be directed towards biofortification of molybdenum, increase in stress tolerance and overall yield increase.

Ten seeds in triplicate were nano-primed with molybdenum nanoparticles, and for control, hydropriming and seeds without any priming treatment were used. The priming was carried out by placing seeds in nano-priming solution of concentration 1, 5, 10, and 15 mg on an orbital shaker at 100 rpm for 6, 12, 18, and 24 hours. The seeds were air-dried and placed on germination paper for calculating the germination parameters like total seeds germinated, average root length, average shoot length, germination percentage, and germination rate. The molybdenum internalization by chickpea seeds was confirmed by atomic absorption spectroscopy.

The nano-primed seeds at a 5 mg concentration and 12 hours showed a significant increase in the germination parameters. At 6 hours, nano-priming showed similar results as hydro-primed seeds, and at 18 hours nano-priming, over-priming effects were noticed. In 24 hours, nano-priming, the seed radicles were protruded in the conical flask itself during priming. The physiological, biochemical, and molecular parameter analyses are underway to validate the above findings. The observations attained so far emphasize that molybdenum nano-priming can be used as a biofortifying agent to aid chickpea plant withstand fluctuating environmental conditions, and to increase its stress tolerance and overall yield.

Evolutionary Conservation and Functional Versatility of Pam18 in Mitochondrial Protein Import and Proteostasis: Insights from *Chlamydomonas reinhardtii*

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Mitochondria are essential organelles relying on TIM23 and PAM complexes for importing nuclear-encoded proteins. While extensively studied in yeast and mammals, their functional diversity in photosynthetic organisms is poorly understood. Using *Chlamydomonas reinhardtii* as a model, we explored Pam18's evolutionary conservation and role, advancing understanding of plant mitochondrial protein import.

Chlamydomonas reinhardtii, a unicellular green alga, retains single orthologs of core PAM components, providing a simplified model for studying mitochondrial protein import in photosynthetic eukaryotes. Functional and structural characterization was performed using AlphaFold modelling, confocal laser scanning microscopy, affinity purification-mass spectrometry, sucrose density fractionation, and native PAGE analysis.

This study demonstrates that the core subunits of the PAM complex—Pam18, Pam16, and mtHsp70—are functionally conserved in *Chlamydomonas reinhardtii*. Gradient fractionation confirmed that Pam18 associates with the TIM23 translocon, reinforcing its role in mitochondrial protein import. Proteomic analyses revealed that Pam18 interacts with proteins involved in translocation, folding, and redox homeostasis, emphasizing its multifunctional role in mitochondrial integrity. Prohibitins were the most abundant interactors, linking Pam18 to mitochondrial proteostasis, similar to its human ortholog DNAJC19. The enrichment of the m-AAA protease FtsH3 suggests that Pam18 functions beyond import, contributing to mitochondrial quality control. The association of CrPam18, Prohibitins, and FtsH3 at the inner membrane integrates protein import and folding with proteostasis, establishing a functional link between translocation and mitochondrial homeostasis. These findings establish *C. reinhardtii* as a simplified yet powerful model for studying mitochondrial protein import, advancing the understanding of mitochondrial protein import systems and their regulatory mechanisms in photosynthetic eukaryotes.

A Little Tilt, a Riddle Large: Investigating Functional Implications of Enantiostyly in *Didymocarpus* (Gesneriaceae)

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Enantiostyly, a polymorphism hypothesized to reduce self-pollination, features flowers with style deflected away from stamen to the left (L-morph) or right (R-morph). Despite Darwin's recognition, its function and evolution remain largely unexplored. To understand this, we studied *Didymocarpus* (Gesneriaceae), a genus in which most species are enantiostylous, exhibiting inter-specific variations in the degree of style deflection and flower size. Here we investigate two hypotheses: 1) enantiostyly with larger style deflection promotes pollen transfer between morphs and reduces selfing, and 2) smaller flower and lesser style deflection is correlated with reproductive assurance through self-pollination in a pollinator-limited condition.

To understand the function of enantiostyly, we conducted pollen tracking using quantum dots and hand-pollinations to determine self/cross-compatibility in a single widespread species with high style deflection. To estimate the possible correlation between stylar deflection and reproductive assurance under pollinator limitation, we conducted floral morphometrics, pollinator observations, pollinator exclusion experiments, and natural fruit-set estimation on five enantiostylous species with varying style deflection. Macro-evolutionary patterns of enantiostyly and flower size were explored by mapping these traits on *Didymocarpus* phylogeny using R packages, ape, and phytool. All computational and molecular work was done at IISER Bhopal.

We found that enantiostylous species with high style deflection promote pollen transfer between flowers of different morphs and maintain an equal proportion of L and R-morphs within the population for effective pollination. Though enantiostyly reduces self-pollination, it appears to be highly pollinator-dependent since all pollinator exclusion experiments failed to sire fruits. The inter-specific variations in style deflection, specifically the presence of species with less style deflections and small flowers appear to have evolved recently in *Didymocarpus*. This potentially avoids pollinator dependency and assures reproduction through increased self-pollination under pollinator limitation. Understanding enantiostyly would help us in improving yields of enantiostylous crops (eg., tamarind, legumes, cassava).

Comparative Analysis of Rosemary (*Rosmarinus officinalis*) Growth in Soil and Hydroponic Dutch Bucket Systems with Hoagland Modification.

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The research paper studies the growth performance of *Rosamarinus officinalis* (rosemary) in organic cultivation using soil with vermicompost and the Dutch bucket hydroponic system. Rosemary is an economically important medicinal and aromatic plant widely used for its essential oil and pharmacological properties. With the increasing application of rosemary in various industries, hydroponics offers a prospective alternative to conventional soil-based cultivation practices by providing the advantage of a controlled nutrient supply.

The experiment was performed using a randomized block design (RBD) with two treatments - black soil and vermicompost and a Dutch bucket hydroponics system with a drip. A month-old rosemary plants were transplanted into a black and vermicompost mixture (1:1) ratio, and in a hydroponics system using a modified Hoagland nutrient solution. Growth parameters such as leaf length, width, plant height, side branching, and inter-nodal length were recorded and analyzed statistically.

The result indicated that the two systems did not significantly differ in leaf length and width, but soil-grown plants exhibited a larger range for plant height and more side branches, although the results were statistically insignificant. Plants grown in the Dutch bucket system displayed a uniform height among all replicas and shortened inter-nodal lengths, suggesting a compact growth habit in hydroponically grown plants. The findings illustrate that the Dutch bucket hydroponic systems can be used as a viable alternative to cultivate rosemary in regions with soil and water problems. More compact and uniform growth in hydroponic systems suggests that it may be advantageous for controlled environment agriculture. Such controlled conditions can be effectively utilized to optimize nutrient formulations to contribute to growth enhancement and secondary metabolite production. This study offers insights into improving the production, efficiency, and economic viability of rosemary.

Evaluating the Role of Oxidative Stress in Clinical Mastitis Among Dairy Goats and Its Amelioration Using Different Antioxidants

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Mastitis is one of the most prevalent diseases affecting dairy goats, leading to substantial economic losses. Oxidative stress, driven by reactive oxygen species (ROS), is recognized as a primary factor in various diseases, including mastitis. However, there is a paucity of studies examining the role of ROS in clinical mastitis specifically in goats. This study was conducted to investigate the relationship between oxidative stress and clinical mastitis in dairy goats.

A total of 313 lactating goats, regardless of age, breed, and stage of lactation, from both organized and unorganized sectors in Jabalpur, were screened over a six-month period. Out of these, 27 goats tested positive for clinical mastitis. Milk and heparinized blood samples were collected for evaluation of parameters included somatic cell counts (SCC), milk pH, and the activities of malondialdehyde (MDA) and reduced glutathione (GSH). Therapeutic efficacy of ascorbic acid and tocopherol as an antioxidants was also evaluated on the basis of amelioration in oxidative stress parameters.

The results indicated significantly higher levels of MDA and significantly lower levels of GSH in goats affected by clinical mastitis compared to healthy goats. Among the milk parameters, goats with clinical mastitis exhibited significantly elevated pH and SCC levels compared to their healthy counterparts. A positive and significant correlation ($P < 0.05$) was observed between SCC and MDA levels. Thus, it was concluded that oxidative stress parameters, specifically MDA and GSH, were significantly altered in goats suffering from clinical mastitis, with a positive correlation observed with SCC. Additionally, the study evaluated the ameliorative effects of various antioxidants in affected goats. On the basis of clinical recovery and restoration of oxidative stress parameters the most effective therapy for clinical mastitis was elicited by Tocopherol (vitamin E) & Sodium selenite in combination with antibiotics. Hence Tocopherol (vitamin E) & Sodium selenite was proved as a better antioxidant in comparison of Ascorbic acid (vitamin C) for the correction of oxidative stress produced by clinical mastitis in goats.

Evaluation Of Chitosan Synthesized Silver Nanoparticles For Enhanced Healing Of Open Wound In Dogs

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Objectives of present study is to synthesize and characterize Ch-AgNPs and evaluate its wound healing efficacy in open wound of dogs.

18 dogs with open wounds were divided into 3 groups of 6 animals each. Group I was treated with povidone iodine, group II with chitosan gel and group III with Ch-AgNPs gel. Wounds were examined grossly on day 0,3,7,14,21 or till healing for evaluation of wound surface area, wound contracture, degree of exudation, peripheral swelling, time of appearance of granulation tissue, evaluation of granulation tissue and colour of granulation tissue, bacteriological culture examination, hemato-biochemical analysis and histological evaluation.

The UV-vis spectrum confirmed the synthesis of AgNPs with characteristic absorbance peak at 425 nm. FESEM images revealed spherical and slightly truncated morphology of the synthesized AgNPs, with a size range of 19 to 85 nm. Wounds of group III animals healed faster, with complete healing observed at day 14, compared to group I and group II animals, which showed complete healing on day 35 and day 21 respectively. Wound contraction, reduction in exudation and peripheral swelling, early appearance of granulation tissue were significantly better in group III compared to group I and II. Group II treated wounds were completely healed at day 21, hence, chitosan gel treated group II was better than povidone iodine treated group I. Haemato-biochemical analysis revealed no significant variations in hemoglobin, PCV, TEC, eosinophils, basophils, total protein, ALT and AST indicating the safety of the Ch-AgNPs gel. Histopathological analysis demonstrated early recruitment of neutrophils, macrophages, lymphocytes, fibroblasts and new blood vessels as well as early well-organized collagenization and higher levels of collagen deposition in the wounds of group III as compared to group I and group II. Therefore, topical application of Ch-AgNPs gel accelerated the healing of open wound in dogs as compared to chitosan gel and povidone iodine ointment treated group.

Effects of *T. indica* and *T. arjuna* on Sodium Fluoride-induced Nephrotoxicity Through Alteration of Nrf2/Kim-1 Signaling Pathway in Rats

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Fluoride contamination in groundwater is a serious issue in Madhya Pradesh, leading to physical weakness, reduced milk and meat quality in affected animals, such as buffalo, sheep and goats. To counteract fluoride toxicity, which is primarily caused by oxidative damage, the antioxidant properties of plants like *T. indica* and *T. arjuna* may be beneficial. This study examines whether these plants can mitigate sodium fluoride (NaF)-induced nephrotoxicity in rats by activating the Nrf2 signaling pathway.

The 1st group received R.O. water, 2nd group received NaF@100ppm in drinking water, 3rd group received NaF@100ppm and extract of *T. indica* @200mg/kg b.w. orally, 4th group received NaF@100ppm + *T. arjuna* extract @50mg/kg b.w. orally and 5th group received ascorbic acid @100mg/kg b.w. orally + NaF@100ppm for 56 days.

Blood and urine samples were collected and renal ultrasound was conducted at the conclusion of the study. The second group (positive control) displayed altered serum and urinary biochemical parameters, a reduction in the levels of antioxidant enzymes and an abnormal kidney structure. In contrast, the third, fourth and fifth groups demonstrated significant improvement. Protein expression analysis indicated that the renal expression of Nrf2 and Kim-1 was normalized in the third, fourth and fifth groups when compared to the second group. Additionally, color doppler sonography revealed a more favourable distribution of blood flow in the third, fourth and fifth groups as opposed to the second group. These findings suggest that extracts from *T. indica* and *T. arjuna* have the potential to mitigate renal damage in rats exposed to sodium fluoride (NaF) by activating the Nrf2 signaling pathway, which in turn enhances the antioxidant capacity of renal tissues. Notably, *T. indica* exhibited superior outcomes when compared to *T. arjuna*.

Physico-chemical Changes in Developed Probiotic Chicken Meat Spread Fermented with *Lactobacillus acidophilus* and Malted Millet Flour

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This study aimed to develop a probiotic chicken meat spread fermented with Lactobacillus acidophilus (LAB) and formulated with malted sorghum flour as a substrate to enhance its functional and nutritional properties. The objective was to evaluate the impact of different levels of malted sorghum flour on the physicochemical characteristics and storage stability of the product.

Chicken meat spread was prepared by incorporating malted sorghum flour at 0, 2, 4, and 6% (w/w) levels, along with Lactobacillus acidophilus at a concentration of 1 million CFU/g. The experimental groups included C (meat spread only), C1 (meat spread with 0% malted sorghum flour + LAB), T1 (2% malted sorghum flour + LAB), T2 (4% malted sorghum flour + LAB), and T3 (6% malted sorghum flour + LAB). The products were analyzed for fresh quality parameters and storage stability at refrigeration (4°C) for 16 days, with assessments of moisture, protein, ether extract, ash content, emulsion stability, cooking yield, free fatty acids (FFA), thiobarbituric acid (TBA), and titratable acidity (TA).

The fresh product study revealed significantly ($p \leq 0.05$) higher moisture content in the T3 group, while protein, ether extract, and ash content were lower in T2 and T3 compared to the control. The T2 formulation exhibited superior emulsion stability and cooking yield, suggesting enhanced textural properties. FFA, TBA, and TA values significantly ($p \leq 0.05$) increased in fermented samples compared to the control, with the trend continuing throughout storage. This study highlights the potential of malted sorghum flour and LAB in enhancing the fermentation efficiency and functional properties of chicken meat spreads. Future research should focus on optimizing ingredient proportions, exploring alternative substrates, and extending shelf-life to improve probiotic meat products for health-conscious consumers.

Evaluation of Phytosynthesized Silver Nanoparticle Coated Polyglactin 910 in Oral Mucosal Surgery of Dogs

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There is a clinical need for strong, biocompatible and antibacterial silver nanoparticle coated suture materials that encourage wound healing, overcome antibiotic resistance and minimize surgical site infections. Uncoated suture materials result post-operative complications like suture dehiscence while commercially available triclosan coated suture materials show resistance against bacteria such as *Pseudomonas* spp., *Streptococci* spp. and can exacerbate the antibiotic resistance. The present study was undertaken with the following objectives (i) *In vitro* evaluation of antibacterial activity of phytosynthesized (*Moringa oleifera*) silver nanoparticle versus triclosan coated polyglactin 910 and (ii) Comparative evaluation of phytosynthesized (*Moringa oleifera*) silver nanoparticle versus triclosan coated polyglactin 910 in wound healing of dogs undergoing oral mucosal surgeries.

In this randomized study, 18 dogs were divided into three groups of 06 animals each. Group I was control group with using uncoated polyglactin 910 suture material. In group II, triclosan coated polyglactin 910 and in group III, MO-AgNP coated polyglactin 910 was used. Clinical and microbiological evaluation was done where healing index were recorded for all the dogs and scoring was done in each group. Microbiological evaluation included colony forming unit and antimicrobial activity of suture material (polyglactin 910).

Group III showed significant reduction in cfu/ml from 3.69 ± 0.18 to 2.77 ± 0.21 in comparison to group II (4.43 ± 0.31 to 4.02 ± 0.39) and group I (3.70 ± 0.17 to 3.36 ± 0.21) on day 0 and 10 respectively. Zone of inhibition against *Staphylococcus sciuri*, *Staphylococcus aureus* (ATCC) and *E. coli* were recorded to be 2mm, 2mm and 3mm, respectively for MO-AgNP coated and 15mm (with slight invasion of bacteria in inhibition zone), 16mm and 3.5mm, respectively for triclosan coated polyglactin 910. Healing index was significantly higher on day 03 (03.66 ± 0.21) and day 10 (4.33 ± 0.21) in group III animals in comparison to 2.50 ± 0.22 and 2.83 ± 0.47 in group II and 2.16 ± 0.31 and 2.50 ± 0.34 in group I respectively.

Impact of Captivity on Behavior and Physiological Stress in Tigers (*Panthera tigris*)

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Human-induced environmental disturbances significantly impact Indian wildlife, especially species like the tiger (*Panthera tigris*), which are wide-ranging and iconic. Zoos play a vital role in their conservation through captive breeding, research, and education. However, artificial zoo environments can sometimes lead to abnormal behaviors, such as pacing and head bobbing, as they do not always accommodate natural behaviors. To ensure the health and welfare of captive tigers, it's essential to monitor stress through biological indicators, such as behavior and cortisol levels, which provide valuable insights into the animals' well-being.

The study examined captive tigers, analyzing faecal samples for cortisol levels along with environmental and biological factors. Results showed that tigers spent 55% of their time exploring and 31% resting. To enhance their environment, it was recommended to provide multiple exploration and resting areas to promote better space use and improve visibility of timid animals. A 0.34 correlation between cortisol levels and stereotypic behaviors indicated that higher stress may cause abnormal activities. Biological factors had no significant impact on behavior or cortisol levels. Enclosures with greater environmental enrichment reduced stereotypic behaviors, while larger enclosures lowered stress, highlighting the importance of well-designed spaces for tiger welfare.

In conclusion, captive tigers require enriched environments that mimic their natural habitats. Enclosures should feature tree cover, water bodies, stones, and dens, along with opportunities for socialization to reduce stress and promote natural behavior. The role of zoo keepers is crucial in managing tiger behavior, and their attitudes can significantly influence the animal’s welfare. Therefore, keepers should be scientifically trained and counseled to improve the care and management of tigers in captivity.

Development of Omega-3 Enriched Chicken Meat: Enhancing Nutritional Value and Health Benefits

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Omega-3 fatty acids are well-documented for their numerous health benefits, and their inclusion in diets has been strongly advocated by health experts. Poultry meat enrichment with ω-3 can be achieved through dietary supplementation with fish oil, marine algae or flaxseed, with flaxseed being a natural and highly effective source. Therefore, this study was conducted with the objective to develop omega 3 fatty acid enriched chicken meat.

The study utilized 240 chicks from five improved germplasms (G1, G2, G3, G4, and G5) developed under AICRP. Chicks were divided into control (T0) and treatment (T1) groups, with T1 receiving a diet supplemented with 10% flaxseed. Birds were fed a starter diet from 0–8 weeks and a finisher diet from 9–14 weeks. Body weight, feed intake, and feed conversion ratio (FCR) were recorded biweekly. At 14 weeks, one bird per replicate was sacrificed to assess carcass traits, meat nutrient composition, fatty acid profile, biochemical parameters, and FADS2 gene expression.

The study found that flaxseed supplementation in broiler diets significantly ($p<0.05$) reduced growth performance, leading to decreased body weight, increased feed intake, and poorer FCR. However, it significantly reduced serum total cholesterol and triglyceride levels. The treatment groups showed a lower ether extract percentage and an improved fatty acid profile, with increased monounsaturated fatty acids, polyunsaturated fatty acids, and ω-6 and ω-3 fatty acids, alongside a reduction in saturated fatty acids and the ω-6:ω-3 ratio. FADS2 gene expression was upregulated in all treatment groups, and higher net profits were observed across all treatment groups compared to controls. It can be concluded that flaxseed supplementation in poultry diets enhances the unsaturated fatty acid profile of the meat, contributing to improved nutritional value.

Impact of Meteorological Conditions of Mahakaushal Region on Semen Production and Cryopreservation of Bucks

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Goats are reliable sources of revenue for farmers and serve as a tool for poverty alleviation, hence, they are known as "poor man's cows." India has 148.88 million goats and Madhya Pradesh ranked fifth in goat population. This study was designed to investigate the effect of seasonal influence on semen production and the impact of melatonin on semen cryopreservation along with developing a practical method of buck semen cryopreservation in bucks.

For this a total of 12 Barbari bucks were selected and routine semen was collected throughout the year on the farm which is situated 25 km apart. Collected semen was diluted with melatonin melatonin-containing tris-based extender and then transferred to the lab. The time of collection to dilution was approximately 2 h and the time taken to reach the laboratory was a further 90 min. The protein profile, total protein, LPO and SOD were evaluated at different seasons. Post-thaw semen evaluation was done by evaluating motility, viability, HOST, acrosomal integrity, mitochondrial status, capacitation, apoptosis and DNA integrity after 24 Hr of freezing.

The THI index indicated severe to moderate heat stress during summer in bucks, reared under the Mahakaushal region, however, mild heat stress was recorded during the late winter. Seasonal influence has been recorded on buck semen parameters throughout the year which were superior in the transition phase and lowest during the summer. However, higher post-thaw motility, livability, plasma integrity and acrosome integrity, high MMP, F-pattern of capacitation, viable sperms and intact DNA percentage were recorded during October-November in Barbari bucks. Correlation between climatic parameters with macroscopic and microscopic semen showed that relative humidity was highly significant and negatively correlated with pH. The correlation between macroscopic and microscopic data showed that Concentration was highly significant and positively correlated with sperm viability and negatively correlated with abnormality.

Diagnostic Evaluation of Nested PCR and Microscopy for Cryptosporidiosis in Goats: Can COWP Gene Based QRT-PCR is Useful in Assessment of Active Cryptosporidial Infections

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The current study sheds information on the *C. parvum* transmission pattern, and molecular testing, sequencing, and phylogenetic analysis would be an appropriate platform in understanding the epidemiological pattern linked to zoonoses to identify workable therapeutic and vaccine targets for controlling Cryptosporidiosis. A total of 80 goat kid samples were gathered, of which 7 (8.75%) were confirmed to be positive by mZN microscopy and 12 (15%) by nested PCR. Analysis of the PCR results on gel electrophoresis revealed band widths of 834bp (18SSU rRNA), 334bp (HSP70), and 850bp (GP60) for the corresponding genes. SspI, VspI, and MboII restriction enzymes were used to genotype 12 *Cryptosporidium* DNA positive isolates for the molecular characterisation, which resulted in the confirmation of *C. parvum* in all samples with mixed infection of *C.bovis* in 4 samples. A quantitative reverse transcription real-time PCR (qRT-PCR) using COWPs in order to assess the severity of the cryptosporidiosis in goat kids was used where COWP6 and COWP4 genes were upregulated, while COWP9 and COWP3 genes were downregulated. A silent mutation was found at the codon CCA–CCC, which is being reported for the first time in goat field isolates, and phylogenetic and sequencing analyses confirmed the presence of the anthropozoonotic IIe subtype.

A Clinical Study on Surgico-Therapeutic Management of Mammary Tumours in Dogs

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This study aimed to document the prevalence, clinical staging and surgico-therapeutic management of mammary tumours in dogs, applying the World Health Organization's TNM classification system, where staging of the tumour was based on the assessment of the extent of primary tumour (T), the condition of the regional lymph nodes (N) and the absence/presence of distant metastasis (M).

The study included 25 female dogs with mammary tumours and prevalence of 1.34%. There were 17 malignant in that carcinoma micropapillary invasive were most common and 8 benign in that simple adenoma being most common cases presented to the Veterinary Clinical Complex, College of Veterinary Science and A. H., MHOW, Indore (M.P.).

The affected dogs belonged to 11 different breeds, with the Labrador Retriever, German Shepherd and Non-Descript breeds being most commonly affected. The average age of affected dogs was 8.72 years, with a higher prevalence in dogs over 6 years old. Tumours were most frequently observed on the right side, with 15 cases and irregular shape and consistency were common. Clinical staging revealed that 32% of cases were in Stage III, followed by Stage IV (24%) and Stage V (24%). Regional and thoracic metastases were observed in several cases. Surgical techniques included simple mastectomy, unilateral mastectomy, en-block dissection, radical mastectomy, and lumpectomy. Histopathological classification revealed that 68% of the tumours were malignant with the most common being carcinoma micropapillary invasive (16%). Malignant tumours showed significantly higher levels of haemoglobin, TLC (neutrophils) and creatinine compared to benign tumours. This study highlights the need for consistent application of TNM staging and surgical techniques for improved diagnosis, for enlightment of the owner about the aggressiveness of the tumour and related prognosis and ultimately for quality of life of patients.

Evaluation of Different Treatment Protocols in Bacterial Cystitis in Dogs

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Urinary tract infection (UTI) is described as the microbial colonization of the urine and any urinary tract organ or as a consequence of retrograde infection from urethra to kidney caused by bacteria, fungi or parasites. Sporadic bacterial cystitis usually referred as uncomplicated cystitis, is the most common morbidity in dogs in which bacterial infection of the urinary bladder with compatible lower urinary tract signs in dogs or cats are observed.

For this study, a total of 2243 dogs presented at VCC, Co.V.Sc. & A.H, Jabalpur, were screened from August-2023 to January-2024. On the basis of clinical signs pertaining to urinary tract disorders, 164 suspected dogs were subjected to haematogical, renal biomarkers and ultrasonographic examination for confirmation of urinary tract disorders. Out of 164 cases, 139 were confirmed for urinary tract disorders and among these, 96 were having upper urinary tract disorders and 43 were having lower urinary tract disorders. A total of 32 dogs were subjected to cultural examination, AST and biochemical tests.

The overall occurrence of UTIs was 6.19% while occurrence of bacterial cystitis was highest among dogs of age group 4-8 years (2.45%), comprising majorly females (2.38%). Out of 32 samples, Escherichia coli was identified as a major uro-pathogen (43.75%) followed by Staphylococcus spp. (25.0%), Pseudomonas spp. (3.13%) and other bacterial isolates (28.13%). Klebsiella spp. remained unidentified in the study. For therapeutic study 16 dogs were randomly selected and categorized into two treatment groups with each treatment group further divided into 02 sub-groups viz. A1, A2, B1 and B2 comprising 04 dogs in each sub-group. The response to therapy in different groups was evaluated on the basis of improvement in haemato-biochemical parameters, urinalysis, ultrasonographical examination and restoration of clinical signs. The most effective therapy for bacterial cystitis was elicited by group A subgroup A1 comprising amoxicillin-clavulanate and cranberry and D-mannose.

40th M.P. Young Scientist Congress

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