

41st

M.P. YOUNG SCIENTIST CONGRESS

FEBRUARY 26 - 28, 2026

ABSTRACTS



M.P. COUNCIL OF SCIENCE AND TECHNOLOGY

Department of Science & Technology, Government of Madhya Pradesh

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



41st M.P. YOUNG SCIENTIST CONGRESS



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Hon'ble Prime Minister's vision of Viksit Bharat @2047 encapsulates for India's transformation into developed nation by 2047. The key pillars to achieve this goal are Science, Technology & Innovation, Enabling policies and governance and Innovation led Industry and Workforce. Government of India has over the last one decade made innovation as priority to realize the goal of Viksit Bharat 2047. At a time when the world is witnessing change at an unprecedented pace with science, technology and innovation being the heart of transformation, it is the youth of India that will define the next chapter of this great nation's story and will play a pivotal role in shaping the future of research, technology and development. The world expects young scientists to go beyond traditional academic research, acting as innovators, communicators, and ethical leaders who can tackle various complex global challenges. It is expected from the young researchers and technologists to develop and implement the technologies needed for future adaption.

The Madhya Pradesh Young Scientist Congress is being organized every year since 1986 with the objective of empowering and investing in the next generation of scientists by involving them in research and integrating their insights, energy and experience to navigate challenges related to various Science subjects. The 41st Madhya Pradesh Young Scientists Congress is being organized by Madhya Pradesh Council of Science & Technology at Bhopal during 26-28 February 2026, in which research papers in 17 S&T subjects are expected to be presented by the young scientists of the State. This is the time when the young researchers and scientists emerging on the horizon of Madhya Pradesh will be identified and felicitated.

I am sure that under the guidance of Hon'ble Chief Minister of Madhya Pradesh, Dr. Mohan Yadav ji, the innovative potential of the Yuva Vaigyanik of the State, combined with the power of technology will prove to be a powerful force on the road to achieve sustainable development goals and realizing the vision of Viksit Bharat@2047 of Hon'ble Prime Minister.

I wish the 41st Madhya Pradesh Yuva Vaigyanik Sammelan a grand success.

Dr. Anil Kothari
Director General
MPCST, Bhopal

41th M.P. Young Scientist Congress

26TH TO 28TH FEBURARY 2026

Subject Index

S.No.	Subject	Page No.
1	Agricultural Sciences	01-20
2	Chemical Engineering	21-25
3	Chemical Sciences	26-45
4	Civil Engineering	46-56
5	Computer Science Engineering and Information Technology	57-72
6	Earth and Atmospheric Sciences	73-81
7	Electrical and Electronics Engineering	82-91
8	Environmental Sciences	92-97
9	Life Sciences	98-115
10	Mathematical Sciences	116-130
11	Mechanical Engineering	131-136
12	Medical Sciences including AYUSH	137-149
13	New Biology (Biotechnology, Biochemistry, Biophysics, Bioinformatics and Molecular Biology)	150-197
14	Pharmaceutical Sciences	198-225
15	Physical Sciences	226-260
16	Plant Sciences	261-267
17	Veterinary Science and Animal Husbandry	268-278
18	Author Index	279-286

Influence on Population Dynamics of Major Insect Pest on Summer Mungbean Under Agro-climatic Conditions of Malwa Region

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Mungbean is one of the important major pulse crops of the country. The groundwater irrigation has brought about significant ecological changes in the hot, dry region. Crop patterns have drastically shifted due to the availability of water for irrigation. Since the insects are, poikilothermic creatures, also prone to climate change. Therefore, it aimed to study the insect pest scenario in changing crop and climate of this region.

Survey and surveillance was done at weekly intervals. Fixed plot survey approach was adopted and observations were taken at weekly interval from three replication. From each replication, 10 plants were randomly examined. Weather data recorded at agro-meteorology unit of experimental area meteorological observatory, Krishi Vigyan Kendra, Mandsaur (Madhya Pradesh) during the crop growth period from March to May, 2025 was used for the study.

Insects *i.e.*, Bihar hairy caterpillar, grasshopper, Spotted pod borer, pod borer, blister beetle, whitefly, thrips, leaf hopper, aphids, stink bugs, coccinellids and spiders were found on mungbean, of these major were whitefly, thrips, pod borer and spotted pod borer. Blister beetle was also observed as voracious and devastating but sporadic. Succession studies classified insect species and their natural predators observed each week into major, minor, and rare pests. Spotted pod borer on 17th SMW (1.3 larvae) and Bihar hairy caterpillar 13th SMW (0.6 larvae) and reached to peak (16.3 and 7.2 larvae). Thrips seen (1.2 thrips) in 12th and maximum (11.2 thrips) in 16th SMW. Mean maximum temperature exhibited mild effect on the decrease of spotted pod borer and increase of *Helicoverpa* and thrips population while minimum had moderate effect. Mean Maximum and minimum Relative humidity demonstrated strong significant positive effect.

Microsatellite Markers-Based Diversity Assessment In Urdbean Genotypes (*Vigna Mungo* L Hepper)

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Genetic diversity in urdbean (*Vigna mungo* L. Hepper), a self-pollinated and nutritionally important Kharif pulse with low productivity due to a narrow genetic base, was assessed using SSR markers.

Forty superior genotypes, selected from ninety-six based on two years (Kharif 2023–2024) of field evaluation at JNKVV, Jabalpur, were analyzed using 58 SSR markers, of which 41 amplified successfully (22 polymorphic, 19 monomorphic).

Polymorphic markers showed PIC values ranging from 0.24 to 0.97, with Cp05325 and LR738A being the most informative; allele frequency ranged from 0.488 to 0.976, gene diversity averaged 0.18, Marker Index (MI) ranged from 0.091 to 0.909, resolving power from 0.042 to 0.524, DP (Discriminating Power) from 0.041 to 3.799, and heterozygosity index (H) from 0.045 to 4.012. UPGMA clustering grouped genotypes into two major clusters, with KUG1179 forming a distinct cluster, while a heatmap of 13 agronomic traits revealed substantial phenotypic variation. The results confirm the efficiency of SSR markers in detecting genetic variability and genetic relationships in urdbean, offering valuable information for breeding and improvement programs.

Mapping Genetic Diversity in Guava Through Advanced Morphological and Biochemical Traits Analysis

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The Genetic variability analysis in 33 guava genotypes revealed wide diversity in fruit shape, color and seed traits. To find out noble that shows dominance for both yield and quality attributes, making them valuable for crop improvement.

The study was conducted with 30 genotypes along with 03 check varieties based on qualitative and quantitative traits. Qualitative and quantitative traits of fruit lead to estimated and analyse the principal component analysis and K mean clustering.

Maximum variability was recorded in fruit shape, fruit shape at stalk end, prominence of neck, surface relief, longitudinal ridges, longitudinal grooves, ridged collar around calyx cavity and pericarp colour of fruit. The highest coefficient of variation was recorded in longitudinal grooves (104%) followed by fruit shape at stalk end (53.07%), pericarp colour of fruit (49.33%), pulp colour (39.98%), fruit shape (38.49%), longitudinal ridges (38.49%), ridged collar around calyx cavity (35.02%) respectively for qualitative traits whereas maximum coefficient of variation for quantitative traits was reported in seed (%) (55.56%) followed by pulp seed ratio (39.55%), weight of 100 seed (34.29%), number of seed (33.38%) and average weight of fruit (30.20%). As per the Principal component analysis, 33 genotypes were distributed in six PCs for the qualitative and quantitative traits. The PC2 was dominated with quality components, while PC4 was mostly dominated with yield attributing traits. Genotypes JG-305, JG-309, JG-310, JG-307, JG-315 and JG-319 present in PC2 and PC4, represents the dominancy of both yield and fruit quality parameters. These identified genotypes are of most important genetic resources for the utilization in crop improvement programme to develop the improved guava genotypes dominated with yield and quality parameters.

Sequential application of various insecticides on Lac insect [*Kerria lacca* (Kerr.)] survival and yield of Baishakhi lac on *Cajanus cajan* (L.) Millsp

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Lac cultivation on pigeon pea (*Cajanus cajan* (L.) Millsp.) is an important agro-forestry-based livelihood system; however, indiscriminate and repeated use of insecticides to manage crop pests and protect lac insects often leads to the insecticide treadmill phenomenon, adversely affecting system sustainability. The present study evaluated the effect of sequential application of commonly used contact insecticides on the survival of lac insect *Kerria lacca* (Kerr.) and on pigeon pea and Baishakhi lac yield. A field experiment was conducted during June 2022–June 2023 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, using six farmer-sourced pigeon pea landraces in a split-plot design with three replications. Three insecticide treatments were tested: alternate application of chlorantraniliprole 18.5% SC followed by emamectin benzoate 5% SG (M1), sequential application of emamectin benzoate 5% SG (M2), and an untreated control (M3). Lac insect population dynamics were recorded at regular intervals from 30 to 150 days after brood lac inoculation (BLI) using digital image-based counting, along with observations on plant growth, pod yield, seed yield, and lac yield parameters. Results revealed that lac insect survival declined progressively with crop age under all treatments, but M1 consistently maintained significantly higher survival by effectively suppressing predators and parasitoids. Repeated application of a single insecticide (M2) showed comparatively reduced efficacy over time, indicating treadmill-like effects. Sequential application under M1 significantly enhanced plant height, pod yield, and lac yield parameters, including stick lac length, weight of lac cells, and mean lac yield per plant. Among the landraces, Korsar-1 consistently supported higher lac insect survival and superior lac yield, particularly in combination with M1. Overall, the study demonstrates that alternating insecticides rather than repeated use of a single molecule, along with the selection of suitable pigeon pea landraces, can improve lac insect survival, crop productivity, and sustainability of the pigeon pea–lac production system.

Rapid Non-destructive Determination of Rice Storage Indicators Using NIR Hyperspectral Imaging

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Rice ageing is accompanied by complex physicochemical transformations that profoundly influence grain quality and market value. This study evaluated short-wave near-infrared hyperspectral imaging (SWIR-HSI, 900-1700 nm) combined with chemometrics as a rapid, non-destructive approach for monitoring key rice storage indicators, including amylose, total starch, peroxide value (PV), and free fatty acids (FFA). Fresh and aged rice samples were classified using partial least squares discriminant analysis (PLS-DA) and k-nearest neighbor (K-NN) classifiers, with the PLS-DA model exhibiting superior classification performance, achieving an overall accuracy of 96% compared with 94% for the K-NN model. For quantitative prediction, full-spectrum partial least squares regression (PLSR) and multiple linear regression (MLR) models were established, among which MLR exhibited superior predictive performance, with coefficients of determination for prediction (R^2_p) ranging from 0.853 to 0.893 and corresponding RMSEP values between 0.216 and 1.624. To improve interpretability and reduce spectral dimensionality, informative variables were selected using interval partial least squares (iPLS), yielding simplified models with strong predictability ($R^2_p = 0.786-0.807$; RMSEP = 0.297-1.782). Furthermore, the optimized models enabled pixel wise visualization of starch, amylose, FFA, and PV distributions within individual rice kernels, providing new insights into storage-induced changes during rice storage. Therefore, the results confirm that NIR-HSI is a reliable and efficient non-destructive technique for rapid assessment of rice ageing and quality monitoring.

Remote Sensing and GIS based Crop Yield Estimation in Jabalpur District of Central India

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Accurate estimation of crop yield at the district level is essential for agricultural planning, food security assessment, and policy formulation. Remote sensing provides a reliable and cost-effective approach for monitoring crop growth and estimating yield over large areas. Vegetable pea is an economically important crop in Madhya Pradesh and is recognized under the One District One Product (ODOP) initiative; however, district-level spatial yield estimation of vegetable pea has received limited attention. The present study aims to estimate the spatial yield of vegetable pea in Jabalpur district of Madhya Pradesh for the year 2021 using remote sensing and GIS techniques.

Sentinel-2A satellite imagery dated 04 December 2021, with 10 m spatial resolution, was used for acreage estimation after atmospheric correction. Maximum likelihood classification was applied to derive land use/land cover and vegetable pea acreage. Yield estimation was carried out using Monteith's (1977) Light Use Efficiency model by integrating satellite-derived parameters such as photosynthetically active radiation (PAR), fraction of absorbed PAR (fAPAR), water stress, temperature, and radiation use efficiency. Image processing and spatial analysis were performed using ERDAS IMAGINE® 2020, and accuracy assessment was conducted using GPS-based ground truth data.

The results revealed that agricultural land covered 58.05% of the study area, with vegetable pea acreage estimated at 31,091.42 ha. Classification accuracy was satisfactory, with kappa coefficients of 0.91 for land use/land cover and 0.85 for pea acreage. Spatial yield varied across the district, ranging from 0 to 60 kg m⁻², and total production was estimated at 66,537.41 tonnes. Comparison with government statistics showed close agreement, with a deviation of less than 4% for production. The study demonstrates the effectiveness of remote sensing-based models for operational, district-level yield estimation of vegetable pea and supports their application in agricultural decision-making.

Influence of Grafting and Gibberellic Acid (GA₃) Levels on Growth and Yield of Brinjal (*Solanum melongena* L.)

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To study the influence of grafting and different GA₃ levels on growth, earliness, fruit characters and yield of brinjal cv. VNR-212. Brinjal productivity is often constrained by biotic and abiotic stresses. Grafting onto *Solanum torvum* and application of Gibberellic acid (GA₃) are promising techniques to enhance plant vigour, earliness and yield in a sustainable manner. A field experiment was conducted during 2024–25 at the Horticulture Field, Faculty of Agriculture, Bhabha University, Bhopal, using a Factorial Randomized Block Design with three replications to evaluate grafting and GA₃ levels. Splice grafting was adopted, and growth and yield parameters were statistically analyzed. Shows that GA₃ @ 75 ppm (T₃) recorded the optimum performance with maximum plant height, higher branching, early flowering and harvesting, and increased fruit number. This indicates that 75 ppm GA₃ efficiently enhances vegetative growth and reproductive efficiency without excessive hormonal effects, making it the most effective and economical treatment.

Spectral Response of Fall Armyworm (*Spodoptera frugiperda* J. E. Smith) Infestation in Maize Crop During Kharif Season

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Maize, a major and the third most important cereal crop in India, is predominantly cultivated during the Kharif season in Madhya Pradesh. The fall armyworm (FAW), *Spodoptera frugiperda*, is a major invasive pest causing significant economic losses. Traditional visual detection of FAW infestation is inefficient, labor-intensive, and time-consuming; however, spectral responses associated with plant damage enable automated detection using proximal remote sensing.

This study analyzed the spectral response of FAW infestation at varying larval densities in maize using hyperspectral proximal remote sensing and machine learning during the Kharif seasons of 2023-24 and 2024-25. Maize plots were covered with nylon net cages to prevent external infestation by FAW and other insect pests, after which known numbers of FAW larvae were artificially released to create controlled infestations. Spectral responses were recorded using a handheld Apogee multispectral spectroradiometer (350-1150 nm), which measured reflectance changes at varying FAW densities with 1 nm spectral resolution.

Results revealed that in the visible region (VIS; 350-700 nm), reflectance values increased progressively with higher larval densities, indicating a positive correlation between infestation levels and VIS reflectance. In contrast, the near-infrared (NIR; 700-1050 nm) region showed markedly reduced reflectance in infested plants compared to healthy ones. Key spectral zones in the visible and NIR regions—around 400–444 nm (blue), 500–555 nm (green), 600–690 nm (red and red-edge), and 740–780 nm and 840–865 nm (NIR)—were consistently significant for characterizing FAW damage in maize. Sensitivity analysis confirmed the diagnostic value of responsive wavelengths such as 505–536 nm and 696–729 nm in the red, red-edge, and NIR regions for detecting FAW stress. These findings concluded that hyperspectral sensing can effectively detect FAW damage in maize fields. The proximal remote sensing is a promising tool for FAW monitoring, offering a more efficient alternative to manual detection.

Multi-trait Evaluation of Wild Soybean (*Glycine soja*) for Qualitative, Yield and Disease Resistance Traits

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Wild soybean (*Glycine soja*), the progenitor of cultivated soybean holds extensive genetic diversity for yield components, disease resistance and adaptive traits. Modern soybean cultivars possess a restricted genetic base, limiting further improvement. This study applied a multi-trait assessment of *Glycine soja* accessions to identify superior donor lines suitable for broadening the genetic base of cultivated soybean breeding programmes.

Twenty five *Glycine soja* accessions were evaluated under field conditions for six quantitative yield traits, key qualitative morphological traits and their response to *Rhizoctonia* aerial blight (RAB), Anthracnose. Traits included flowering and maturity duration, plant height, pods and seed yield, along with flower, leaf and pubescence characteristics. Disease reactions were scored under natural conditions using a standard scale.

Principal component analysis showed that the first two principal components explained 65.7% of the total variation, with PC1 (44.2%) representing yield and yield-contributing traits and PC2 (21.5%) associated with phenological traits. Factor analysis grouped traits into two major factors with a mean communality of 0.66. Factor 1 was strongly associated with total pods per row (TPR), seed yield per plant (SYP), row yield (BLKY) and plant height, whereas Factor 2 was dominated by days to flowering and days to maturity.

The Multi-trait Genotype–Ideotype Distance Index (MGIDI) integrated these traits by combining factor scores with a predefined ideotype, enabling simultaneous selection for high yield and early maturity. MGIDI-based selection at 20% intensity resulted in genetic gains for SYP (29.8%), BLKY (99.5%), TPR (104.0%), and plant height (52.0%) with reductions in days to flowering (–12.1%) and maturity (–3.9%), indicating balanced improvement. Based on MGIDI values, EC1165790, EC1165933, EC1165820, and EC1165814 were superior. Trait-wise ranking revealed EC1165897, EC1165820, EC1165789, and EC1165879 as high-yielding and tolerant to anthracnose and *Rhizoctonia* aerial blight. The convergence of MGIDI selection, yield and disease tolerance highlights EC1165820 and EC1165897 as promising elite donors for soybean improvement.

Tray Drying Behaviour of Fresh Water Chestnut (*Trapa natans*) Chips at Varying Slice Thicknesses

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The present study investigated the effect of slice thickness on drying kinetics and moisture removal behavior of fresh water chestnut (*Trapa natans*) chips during hot-air tray drying. Fresh water chestnuts were peeled and sliced into four uniform thicknesses (2 mm, 3 mm, 4 mm, and 5 mm) and dried at three temperatures (60°C, 80°C, and 100°C) in a laboratory-scale tray dryer at a constant air velocity of 1 m s⁻¹. Moisture loss was recorded at regular intervals until equilibrium moisture content was achieved, and drying rate characteristics were analyzed.

Results revealed that both slice thickness and drying temperature significantly affected the drying behavior of water chestnut chips. Drying time decreased with decreasing slice thickness and increasing drying temperature. At 60°C, drying was slow for all thicknesses, with 5 mm slices requiring the longest drying time due to higher internal moisture resistance, while 2 mm slices reached equilibrium moisture content faster. Increasing the temperature to 80°C enhanced moisture removal and resulted in steeper drying curves, particularly for intermediate slice thicknesses. The highest drying rates were observed at 100°C, especially during the initial drying period, followed by a falling rate phase governed by internal moisture diffusion.

Thinner slices exhibited higher initial drying rates due to a greater surface area-to-volume ratio, whereas thicker slices showed prolonged drying durations. Based on drying kinetics and quality attributes, tray drying at 100°C using slice thicknesses of 3–4 mm is recommended as the optimum condition for producing stable, good-quality dried water chestnut chips suitable for further processing and value addition. The study confirms that drying of water chestnut chips occurs entirely in the falling rate period and highlights the importance of slice thickness and temperature optimization for efficient tray drying operations.

Identification of Stable and Terminal Heat-Tolerant Bread Wheat Mutant Genotypes

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Wheat (*Triticum aestivum* L.), India's second most important cereal, faces severe productivity losses due to terminal heat stress that accelerates grain filling and reduces yield and quality. An integrated physio-biochemical, molecular, and multi-environment stability analysis framework enables a holistic dissection of heat tolerance mechanisms and the precise selection of climate-resilient, high-yielding, and stable genotypes.

The present study evaluated thirty-four gamma-ray-induced bread wheat mutant genotypes developed from Borlaug-100, along with two check varieties (HD 2967 and GW 322), in a randomized complete block design across timely, late, and very late sowing environments during the Rabi seasons of 2023-24 and 2024-25 at RVSKVV, Gwalior (M.P.), with laboratory analyses conducted at the Biotechnology Research Centre, RVSKVV, Gwalior (M.P.).

Combined analysis of variance revealed highly significant ($P < 0.01$) effects of genotypes, environments, and genotype \times environment interactions for grain yield and its contributing traits, indicating substantial genetic variability and differential responses to terminal heat stress. Genetic parameter estimates showed high heritability coupled with high genetic advance for biological yield per plot, suggesting the predominance of additive gene action and considerable scope for effective selection. Stability analyses using Eberhart and Russell and AMMI models identified mutant genotypes TGW 25 and TGW 134 as consistently high-yielding and widely adapted across environments. These genotypes exhibited superior physiological efficiency, enhanced osmolyte accumulation, stronger antioxidant defense mechanisms, and appreciable molecular diversity under heat stress conditions. Conclusively, the results demonstrate that mutation breeding, integrated with multi-environment stability analysis and physio-biochemical and molecular characterization, is an effective strategy for developing terminal heat-tolerant and climate-resilient wheat genotypes. The stable performance of TGW 25 and TGW 134 highlights their potential for deployment in climate-smart wheat breeding programs and warrants their consideration for inclusion in national varietal testing for future release.

DNA Barcoding Reveals Species-Specific Markers in Minor Millets (Poaceae): A Step Toward Taxonomic Clarity and Conservation

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Minor millets are climate-resilient and nutritionally climate-resilient cereals of the family Poaceae, widely cultivated in semi-arid and drought-prone regions of India. Despite their agricultural and health significance, accurate identification of minor millet species remains challenging due to close morphological similarity, polyploidy, and limited investigative traits. The research study aimed to generate reliable DNA barcodes for minor millets to resolve taxonomic ambiguities and support conservation and utilization of genetic resources.

The research was conducted at the Biotechnology Centre, JNKVV, Jabalpur, using 60 plant samples representing 15 species of minor millets collected from various regions of India. The genomic DNA was isolated using a modified CTAB method and four universal DNA barcode loci, namely *ITS2*, *rbcL*, *atpF-atpH*, and *trnL*, were amplified and sequenced. Further data were analyzed using standard bioinformatics tools, including BLAST, BOLD, TaxonDNA and MEGA 11 were performed sequence alignment, similarity searches, genetic distance estimation and phylogenetic analyses.

The high amplification and sequencing success were observed across barcode loci, with *atpF-atpH* and *rbcL* showing superior universality. The barcode loci, *ITS2* exhibited the highest species discrimination efficiency, while multilocus combinations significantly improved resolution among closely related taxa. Genetic distance analysis revealed greater interspecific than intraspecific variation, confirming a clear barcode gap. The phylogenetic analyses using UPGMA and Maximum Parsimony methods recovered most species as distinct monophyletic clusters. Several DNA barcode sequences were generated and submitted for the first time, strengthening molecular reference databases. The study demonstrates that DNA barcoding is a robust and efficient tool for accurate species identification of minor millets, contributing to taxonomic clarity, germplasm authentication, conservation planning and future crop improvement programs.

Unveiling *Nesidiocoris tenuis* as a Sesame Pest: From Taxonomic Identity and Loss Quantification to Genotype Screening and Biochemical Resistance Mechanisms

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Nesidiocoris tenuis has emerged as a major pest of sesame in India, resulting in substantial yield losses due to sap feeding at various crop stages. However, integrated management strategies for this pest remain unavailable to farmers. The present study identifies the pest, quantifies its damage using multi-season data, evaluates sesame genotypes for resistance, and investigates the underlying biochemical mechanisms of resistance. This comprehensive approach facilitates the development of sustainable management solutions.

Field experiments at JNKVV, Jabalpur (Kharif 2023-2024) used caged infestations (0-16 bugs per plant), open-field thiamethoxam sprays, and a randomized block design to screen 58 sesame genotypes under natural pest pressure. This study assessed pest populations, growth, and yield, as well as biochemical traits such as phenols, tannins, and proteins, using ANOVA, regression, and correlation analyses.

Pooled data showed peak bug populations of 9.3 per plant during flowering, causing a 47% yield loss (from 26.2 to 13.9 q/ha; $R^2 = 0.946$). Screening identified AT-467 and TKG-22 as resistant varieties (<1.4 bugs per plant) with higher phenol (345 mg/100g) and tannin (208 mg/100g) levels, and these levels showed negative correlations ($r = -0.615$ to -0.945) with density. The economic injury threshold of 0.23 bugs per plant (first spray EIL) guides targeted spraying, while biochemical markers support HPR breeding. This approach equips farmers with scouting tools, thresholds, improved seeds, and future varieties, leading to 20-40% profit increases.

Evaluation of Soybean Genotypes for Resistance to Yellow Mosaic Disease under Natural Epiphytotic Conditions

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Glycine max [L.] Merrill is a key legume crop with high nutritional and economic value, yet its productivity in India is constrained by Yellow Mosaic Disease (YMD), caused by mungbean yellow mosaic virus (MYMV) and mungbean yellow mosaic India virus (MYMIV), transmitted by *Bemisia tabaci*. A two-year field study conducted during *Kharif* 2024 & 2025 at Zonal Agricultural Research Station, Morena, evaluated 153 soybean genotypes with 4 standard checks *viz.*, JS 97-52, JS 21-72, RVS-2001-4 and RVSM-35 for YMD response under natural epiphytotic conditions. Disease incidence was measured as the coefficient of infection (CI) and genotypes were categorized as highly resistant (HR), resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S) or highly susceptible (HS). Coefficient of Infection for both years values ranged from 2.5 to 80, reflecting presence of considerable genetic variation. Among the genotypes, 20 were HR, 54 R, 37 MR, 21 MS, 8 S and 13 HS. The Shannon–Weaver diversity index ($H' = 1.614$) indicated high diversity among the genotypes for YMD resistance, suggesting presence of a broad spectrum of genetic variability among the genotypes. Resistant and moderately resistant genotypes exhibited stable performance across both years, highlighting their potential for direct cultivation and use as donors in future breeding programmes. Conversely, susceptible and highly susceptible genotypes provide contrasting material for resistance screening and selection. The study identifies valuable sources of YMD resistance and underscores the importance of integrating resistant genotypes into breeding programs to enhance sustainable soybean production and food security in India.

Effect of Eccentricity on Uniformity Thickness of Chapati

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The geometric uniformity of chapati plays a critical role in determining its physical, textural, and sensory quality. An ideal chapati is expected to possess a near-circular shape and uniform thickness, which promote even baking, proper puffing, and desirable texture. However, shape irregularity is frequently introduced during both manual and mechanized rolling due to uneven deformation of viscoelastic dough. Such irregularity can be quantitatively expressed in terms of eccentricity, a measure of deviation from a perfect circular form. Despite its practical importance, the influence of eccentricity on chapati quality has received limited scientific attention. The present study investigates the effect of varying levels of rolling-induced eccentricity on the quality attributes of chapatis prepared from whole wheat flour. Chapati discs with low, medium, and high eccentricity were produced through controlled variation in rolling technique and dough sheeting conditions. Geometrical parameters, including major and minor diameters, thickness distribution, and shape factor, were measured to quantify eccentricity and associated non-uniformity. Key quality attributes—namely puffing index, browning uniformity, moisture loss, firmness, rollability, and overall sensory acceptability—were evaluated using a combination of instrumental methods and sensory panel assessment. The results showed that increasing eccentricity led to significant non-uniformity in thickness, which disrupted heat and mass transfer during baking. Highly eccentric chapatis exhibited incomplete or irregular puffing, localized over-browning or charring, increased firmness, reduced pliability, and a higher tendency to tear during handling. Sensory evaluation revealed a marked decline in consumer acceptability with increasing eccentricity, particularly with respect to appearance and texture, while flavour remained largely unaffected. Statistical analysis confirmed a significant negative correlation between eccentricity and overall quality score, establishing shape uniformity as a key determinant of chapati quality.

Optimizing Operational Parameters of Threshing Cylinder for Kodo Millet by using RSM

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Kodo millet (*Paspalum scrobiculatum L.*) is an important minor millet crop in India, particularly cultivated in tribal and rainfed regions. Traditional threshing methods are labor-intensive, time-consuming, and result in low output and poor grain quality. Optimization of threshing cylinder operational parameters is essential to improve threshing efficiency while minimizing grain damage, especially for low-cost, pedal-operated threshers suitable for small and marginal farmers.

A spike tooth threshing cylinder was designed and developed for kodo millet threshing. The effects of three operational parameters—feed rate (27–33 kg h⁻¹), pedalling speed (30–45 rpm), and concave clearance (3–7 mm)—on threshing efficiency and grain damage were evaluated. Optimization was carried out using Response Surface Methodology (RSM) with a Central Composite Rotatable Design (CCRD). Twenty experimental runs were conducted, including five replications at the central point. Statistical analysis and model development were performed using Design-Expert software to establish second-order polynomial regression equations.

The developed quadratic models were significant ($p < 0.001$) with high coefficients of determination ($R^2 = 0.90$ for threshing efficiency and $R^2 = 0.94$ for grain damage). Numerical optimization revealed optimal operational parameters of feed rate 31 kg h⁻¹, concave clearance 5 mm, and cylinder speed approximately 40 rpm. Under these conditions, the predicted threshing efficiency and grain damage were 95.5% and 0.06%, respectively. Validation experiments showed close agreement with predicted values, yielding 96.2% threshing efficiency and 0.12% grain damage. The results confirm that optimized operational parameters significantly enhance threshing performance while maintaining minimal grain damage.

AMMI Analysis and Heat Selection Indices for Yield and Physiological Stability in Chickpea (*Cicer arietinum* L.)

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High temperature stress remains a critical bottleneck for chickpea productivity globally. This study aims to evaluate the genotype-by-environment (G X E) interaction and identify heat-tolerant genotypes using multivariate AMMI analysis and diverse selection indices. The primary objective was to differentiate additive and multiplicative variance to characterize stability and specific environmental adaptation across six distinct environments.

Field experiments utilized thirty chickpea genotypes evaluated over two years under varying sowing dates to induce differential heat stress. Statistical analysis integrated the AMMI model (AMMI 1 and AMMI 2 biplots) to assess stability via IPCA scores. Eight heat selection indices, including SSI, STI, and YSI, were calculated to rank genotypes, complemented by correlation analysis of physiological traits like LAI, NAR, and CTD.

AMMI analysis revealed that PCA I and II explained 69.51% of the G X E interaction, identifying JG2021-1617 and ICCV181603 as highly stable across environments. Heat indices consistently ranked ICCV181106 and ICCV181603 as top-performing lines under late-sown conditions. Physiological correlations indicated that seed yield per plant is strongly driven by biomass duration ($r = 0.396^*$) and net assimilation rate, while canopy temperature depression served as a vital indicator of thermal resilience. These findings emphasize that integrating AMMI stability with physiological efficiency is essential for developing heat-resilient cultivars. The identified genotypes, particularly ICCV181603 and ICCV181106, provide a robust genetic base for future breeding programs targeting terminal heat stress environments, ensuring sustainable chickpea production in changing climatic scenarios.

Response of *Nigella* (*Nigella sativa* L.) to IW/CPE-Based Irrigation and Mulching in Madhya Pradesh

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The present study has been conducted to examine the relationship between seed yield, water use efficiency and water productivity of *Nigella* in the presence of different levels of irrigation and mulching as objectives of deciding on an effective and sustainable system of water management in seed spice production.

The research was designed in a split-plot format where the four irrigation rates (1.0, 0.8, 0.6 and 0.4 IW/CPE) were used as the main plots and the four levels of mulching (silver black polythene, black polythene, organic mulch and no mulch) as subplots. Irrigation was also scheduled on the basis of the daily evaporation data and rainfall data take from Indian Meteorological office, Jabalpur (M.P.)

The results indicated that the highest seed yield was observed at 1.0 IW/CPE ($1011.73 \text{ kg ha}^{-1} \text{ mm}^{-1}$), but deficit irrigation was more effective in enhancing the water-use parameters, with the highest WUE ($4.43 \text{ kg ha}^{-1} \text{ mm}^{-1}$) and WP (0.44 kg m^{-3}) Silver black polythene mulch achieved more seed yield ($949.34 \text{ kg ha}^{-1}$), WUE ($3.99 \text{ kg ha}^{-1} \text{ mm}^{-1}$), and WP (0.40 kg m^{-3}) when compared to other mulches. The correlation analysis made it clear that the seed yield had a significant negative correlation with the WUE ($r = -0.631$) and the WP ($r = -0.616$) whereas the WUE and the WP had significant and positive correlation ($r = 0.995$). This research shows that Silver black polythene mulch and deficit irrigation have proven to be an effective water management method to use in Production of *Nigella*.

Weed Ecology and Integrated Management in Dry Direct-Seeded Rice: System-Level Productivity, Economics, and Food Safety in Rice–Wheat–Greengram Cropping System

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Dry direct-seeded rice (DSR) adoption is constrained by complex weed dynamics under aerobic conditions, necessitating system-level management strategies. This investigation characterized weed ecology, seed bank dynamics, and herbicide efficacy in a rice–wheat–greengram cropping system. The study aimed to develop integrated, sustainable weed management protocols balancing productivity, economics, and food safety.

A two-year field experiment (2022–2024) at ICAR-Directorate of Weed Research, Jabalpur, evaluated seven weed management treatments in DSR using Randomized Block Design. The study assessed phytosociological shifts, seed burial ecology, and herbicide residue levels. System competence was quantified through rice equivalent yield and economic returns to determine the optimal strategy for the Central Indian plains.

Biologically, *Echinochloa colona* emerged as the keystone species (IVI 142.4), with seed burial experiments confirming emergence from 9 cm depth. This staggering phenology necessitates sequential herbicides, as pre-emergence efficacy declined from 100% (0–3 cm) to 50% (7–9 cm). Inadequate control caused distinct biological collapse; the untreated system deteriorated from stable returns to net loss (-₹29,458/ha) within two years due to exponential seed bank amplification. Conversely, treatment T₄ (pendimethalin *fb* bispyribac-sodium + metsulfuron/chlorimuron) proved economically optimal, achieving maximum system net returns (₹1,84,613/ha) and B:C ratio (2.65). Crucially, herbicide residues in grain remained 2–5 fold below Codex safety limits, assuring consumer safety. The study establishes that single-season weed neglect triggers cascading system productivity failures. Thus, adoption of T₄ offers a holistic, robust solution for sustainable intensification, ensuring yield stability against biological constraints in the rice–wheat–greengram cropping system.

Enhancing Soil Biological Health and Nutrient Availability of Maize through Different System of Nutrient Management in Bundelkhand Region

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The study on enhancing Soil biological health and Nutrient Availability of maize through different system of nutrient management in Bundelkhand Region was conducted at Mahatma Gandhi chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Stana (M.P.).

The experiment was laid out in Randomized Block Design with thirteen treatments replicated three times. Treatments comprised of [T₁ - Control, T₂ - Seed treatment with Beejamrit + Foliar application of jeevamrit + Mulching, T₃ - Seed treatment with Beejamrit + Soil application of jeevamrit + Foliar application of jeevamrit + Mulching, T₄ - Seed treatment with Beejamrit + Soil application of Ghana jeevamrit + Foliar application of jeevamrit + Mulching, T₅ - Farm Yard Manure 24 t ha⁻¹, T₆ - Vermicompost 8 t ha⁻¹, T₇ - Poultry Manure 5.8 t ha⁻¹, T₈ - 100% RDF + *Azotobacter* + PSB, T₉ - 75% RDF + 25% FYM + *Azotobacter* + PSB, T₁₀ - 50 % RDF + 50 % FYM + *Azotobacter* + PSB, T₁₁ - 75 % RDF, T₁₂ - 100 % RDF and T₁₃ - 125 % RDF].

Soil biological properties and soil chemical analysis were estimated after harvest of crop. The significantly maximum population of fungi, bacteria and actinomycetes up to maximum extent (5.6×10^{-4} cfu, 36.98×10^{-7} cfu and 48.7×10^{-5} cfu g⁻¹ soil, respectively), Urease enzymes activity ($48.848.8 \mu\text{g NH}_4 + \text{g}^{-1} \text{ soil hr}^{-1}$), dehydrogenase activity ($83.93 \mu\text{g TPF g}^{-1} \text{ soil } 24 \text{ hr}^{-1}$) and alkaline phosphatase ($70.8 \mu\text{g PNP g}^{-1} \text{ soil hr}^{-1}$) populations were recorded at harvest of crop with the application of T₄ (Seed treatment with Beejamrit + Soil application of Ghana jeevamrit + Foliar application of jeevamrit + Mulching) followed by T₃ (Seed treatment with Beejamrit + Soil application of jeevamrit + Foliar application of jeevamrit + Mulching). At harvest of crop, significantly maximum available N, P and K were noted under T₉ (75% RDF + 25% FYM + *Azotobacter* + PSB) i.e. 212.5, 20.23 and 303.7 kg ha⁻¹, respectively. The highest grain (6783.4 kg ha⁻¹) and stover yield (7652.7 kg ha⁻¹) was obtained with the application of T₉ (75% RDF + 25% FYM + *Azotobacter* + PSB).

Electrochemical Sensor Based on Polydopamine-Coated Silver Nanowire/Defect-Ridden UiO-66-NH₂ Nanocomposites for Trace Detection of Cd(II) and Pb(II) Ions in Water

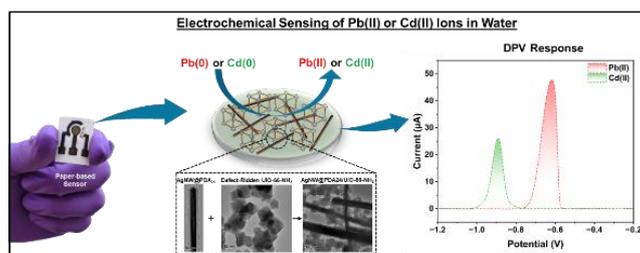
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Due to growing environmental and health concerns associated with toxic heavy metal ion (HMI) pollution, it becomes necessary to develop fast, highly sensitive, and selective detection methods. Herein, an electrochemical sensor based on a glassy carbon electrode (GCE) modified with a thin film of polydopamine-coated silver nanowire (AgNW@PDA)/defect-ridden UiO-66-NH₂ nanocomposites (AgNW@PDA/UiO-66-NH₂) was developed for trace detection of cadmium (Cd(II)) and lead (Pb(II)) ions in water.

The electrochemical performance of the proposed AgNW@PDA_t/UiO-66-NH₂/GCE sensor was then optimized by varying the polymerization time (t) of dopamine on the AgNWs. Compared to defect-ridden UiO-66-NH₂, AgNW@PDA_t/UiO-66-NH₂ nanocomposites offered a higher electrochemically active surface area, a better standard heterogeneous electron transfer rate constant, and enhanced sensing performances. The AgNW@PDA₂₄/UiO-66-NH₂ nanocomposite (t = 24 h) showed the best electrochemical properties and was further utilized for both individual and simultaneous detection of HMIs using differential pulse voltammetry (DPV).

The optimized AgNW@PDA₂₄/UiO-66-NH₂/GCE sensor achieved a low limit of detection (LOD) of 25.2 nM for Cd(II) and 9.8 nM for Pb(II), and high sensitivity of 7.18 and 18.2 $\mu\text{A } \mu\text{M}^{-1} \text{cm}^{-2}$, along with a wide linear range of 0.05–1.1 and 0.05–0.7 μM , respectively, for individual detection. The AgNW@PDA₂₄/UiO-66-NH₂/GCE exhibited a higher selectivity for Pb(II) ions in the presence of other interfering metal ions, depicting a recovery rate of ~97–100% over other HMIs. The sensor further demonstrated good stability, repeatability, and reproducibility. The practical applicability of the developed sensor was also confirmed by the successful detection of Cd(II) and Pb(II) ions in spiked tap water samples. Finally, a paper-based flexible sensor was fabricated using the optimized AgNW@PDA₂₄/UiO-66-NH₂ ink, yielding a linear range of 5–60 μM and LOD values of 81 and 153 nM for Pb(II) and Cd(II) ions, respectively, thus confirming its potential for on-site monitoring of HMIs in real water samples.



Evaporation-Induced Energy Harvesting via a Zn-Imidazole Intercalated Graphene Oxide Nanogenerator

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Growing concerns over climate change and energy sustainability have intensified research efforts toward green and zero-emission energy harvesting technologies. Among emerging strategies, water evaporation-induced generators (WEIGs) have attracted considerable interest because they harness ambient thermal energy and convert it into electrical power via water evaporation through ion-selective nanofluidic pathways. This approach represents an environmentally benign and sustainable route for electricity generation. In particular, membranes containing charged nanochannels provide an efficient platform for WEIGs owing to their strong nanocapillary effects and selective ion transport behavior. In this work, we demonstrate the fabrication of a graphene oxide (GO) membrane intercalated with Zn-imidazole complexes (ZnIm) and investigate its performance in in-plane ionic transport-based energy harvesting. The resulting GO-ZnIm membrane exhibits surface-charge-governed ion transport at low electrolyte concentrations, while steric confinement becomes dominant at higher concentrations. The membrane shows a high cation selectivity, achieving a K^+ transference number of 0.91. When employed in a WEIG device, the membrane delivers a stable open-circuit voltage of 0.75 V and a current output of 0.4 μA in deionized water. Remarkably, even under high ionic strength conditions (1 M KCl), the voltage output remains as high as 0.5 V, underscoring its suitability for seawater-based energy harvesting. The nanogenerator attains a maximum power density of 157.5 $\mu\text{W cm}^{-3}$. Moreover, the output voltage scales linearly with the number of devices connected in series; three integrated units generate a combined voltage of 2.2 V, which is sufficient to charge a capacitor and illuminate a red LED. These results highlight the scalability and practical potential of the GO-ZnIm membrane based WEIG system for real-world sustainable energy applications.

Lateral Size-Dependent Hydrogen Storage Performance of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene

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$\text{Ti}_3\text{C}_2\text{T}_x$ MXenes have attracted significant attention as potential hydrogen storage materials owing to their high surface area, tunable surface terminations, and layered structure. In this study, $\text{Ti}_3\text{C}_2\text{T}_x$ MXene flakes with systematically tailored lateral sizes were synthesized using controlled etching and delamination processes, and their hydrogen storage behavior was investigated using volumetric adsorption measurements over a wide temperature range, including cryogenic conditions. A strong dependence of hydrogen uptake on lateral flake size was observed, demonstrating the critical role of dimensional control in MXene-based storage systems. Among the investigated samples, smallest flake size exhibited the highest hydrogen storage capacity of 5.26 wt% at 173 K, while MXenes with larger lateral dimensions showed improved hydrogen storage performance at higher temperatures. These results reveal that lateral size influences adsorption energetics, diffusion pathways, and interlayer interactions, establishing lateral size optimization as a key design parameter for enhancing the hydrogen storage performance of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene and its broader applicability in energy storage and advanced functional materials.

Reusable, Compressible and Hydrophobic Graphene-Based Sponge for Efficient Oil-Water Separation

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Water is an indispensable resource for ecological balance and sustainable development. However, the continuous discharge of oily wastewater from industrial effluents, frequent oil spill incidents, and domestic activities has emerged as a serious environmental concern, posing significant threats to aquatic ecosystems and water quality. The development of lightweight, reusable, and highly efficient materials for oil-water separation remains a major challenge due to limitations associated with complex fabrication processes, poor scalability, limited recyclability, and insufficient mechanical durability.

In this work, a simple, scalable, one-step, and template-free fabrication strategy is employed to develop reduced graphene oxide/poly(vinylidene fluoride-co-hexafluoropropylene) (rGO/PVDF-HFP) composite sponges for oil-water separation. The fabricated composite sponges exhibit an ultralight structure with a density of $\sim 0.065 \text{ g/cm}^3$ and a high porosity of $\sim 96.4\%$. The morphological, structural, and surface characteristics are systematically analyzed using field-emission scanning electron microscopy, X-ray diffraction, Raman spectroscopy, and water contact angle measurements.

The rGO/PVDF-HFP sponges exhibit a three-dimensional interconnected porous architecture, intrinsic hydrophobicity with a water contact angle of $\sim 128^\circ$, and strong oleophilic behavior, enabling rapid and selective oil uptake. Notably, the composite sponge demonstrates excellent mechanical performance, sustaining a compressive strength of 74 kPa with approximately 94% recovery under 50% compressive strain, which ensures durability during repeated use. The sponge achieves efficient removal of a wide range of oils and organic solvents, exhibiting high separation efficiencies of $\sim 95 - 97\%$ along with stable recyclability over multiple cycles. These results highlight the strong potential of rGO/PVDF-HFP composite sponges as promising candidates for practical oily wastewater treatment and environmental remediation applications.

Dual-Mode Optical Detection of Arsenic Using a Sustainable Bio-Derived Graphene Quantum Dot–Chitosan–PEG Fluorescence Sensor

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Arsenic contamination of drinking water remains a critical environmental and public health concern, particularly in groundwater-dependent regions with limited access to centralized analytical facilities. The objective of this study is to develop a sustainable, sensitive, and field-deployable optical sensing platform for arsenite (As^{3+}) detection using bio-derived nanomaterials, addressing the dual challenges of environmental sustainability and decentralized water quality monitoring.

The sensing material was fabricated using graphene quantum dots synthesized from potato peel biomass through an environmentally benign route and subsequently functionalized with chitosan and polyethylene glycol to enhance aqueous stability and surface functionality. The nanocomposite was characterized using optical and spectroscopic techniques to evaluate fluorescence behaviour and stability. Arsenite detection was investigated through fluorescence intensity quenching and lifetime modulation, and sensor performance was assessed in terms of sensitivity, selectivity, reproducibility, and operational stability using real drinking water samples.

The developed sensor demonstrates dual-mode arsenite detection arising from strong surface coordination and photoinduced electron transfer interactions at defect-rich graphene quantum dot interfaces. A high sensitivity with a detection limit of 9.3 ppb, below the World Health Organization guideline for drinking water, was achieved along with excellent selectivity against competing ions. Reliable performance in real water matrices confirms robustness under environmentally relevant conditions. Data-assisted spectral analysis improves signal reliability, while compatibility with portable, AI-assisted, and IoT-enabled optical readout systems supports decentralized and real-time monitoring. By integrating sustainable material design with dual-mode optical sensing, this work provides a practical and environmentally responsible solution for arsenic monitoring, contributing to safe drinking water management, public health protection, and environmental sustainability.

Potential Bioactive Ligand and its Divalent M (II) Complexes: Synthesis, Physicochemical Characterization, DFT Calculations and Biological Applications

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Bioactive ligands are a diverse group of compounds with significant biomedical applications, particularly in drug design and therapeutic treatments. A key feature of these ligands is the carbon-nitrogen double bond, which plays a crucial role in biochemical interactions and synthetic pathways. This bond enhances their ability to coordinate with metal ions, forming stable complexes with various biological and catalytic properties. Their versatility arises from the wide range of synthetic methods available for their modification, allowing for tailored applications in medicine, materials science, and catalysis. This study provides a novel perspective on bioactive ligands, exploring their unique properties and potential applications.

A novel bioactive ligand (L) was synthesized using 5-bromo-2-methoxybenzaldehyde and 3-amino-4-chloro-6-nitrophenol. Mononuclear Ni(II) and Cu(II) complexes were prepared and thoroughly characterized using FT-IR, NMR, UV-visible spectroscopy, ESI-MS, thermogravimetric analysis (TGA), and cyclic voltammetry (CV). Spectroscopic data confirmed the formation of stable metal complexes, exhibiting a six-coordinated pseudo-octahedral geometry. Thermal studies demonstrated their stability, while electrochemical analysis provided insights into their redox behavior. The metal complexes exhibited complete solubility in DMSO and DMF, making them suitable for further biological and catalytic applications. This study highlights the structural and functional significance of these newly synthesized coordination compounds.

Bioactive ligand and its metal complexes are biologically active. Metal complex Cu (II) shows better antimicrobial activities i.e. antifungal and antibacterial.

TEMPO-Derived Redox-Active Organic Compound as an Efficient Electrocatalyst for N-heterocycle Synthesis Electrochemically

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The immobilization strategy onto electrode surfaces ensures sustained electronic interaction with the electrode, which offers broad applicability towards N-heterocycle synthesis on a preparative scale for molecular electrocatalysis. The development of TEMPO-immobilized systems as heterogeneous electrocatalysts has emerged as a promising alternative for electrocatalytic N-heterocycle synthesis towards achieving a sustainable reaction pathway.

This study presents the synthesis of TEMPO-tethered NMI-CAP-T as a heterogeneous electrocatalyst for the electrochemical N-heterocyclic benzimidazole synthesis with a wide substrate scope in a one-pot method using an undivided electrolytic cell comprising Pt-mesh as WE and Pt-wire as CE under safer, green organic solvent/water conditions with an application of constant current of 10 mA for 3 h, achieving excellent yields, high turnover frequencies (TOFs), stability and good reproducibility.

Cyclic voltammetric analysis of NMI-CAP-T revealed that the material is redox-active, with an oxidative potential of 0.63 V and a reduction peak at 0.43 V, whereas the g value of 1.98 from the ESR spectrum confirmed the presence of a free radical. The oxidation of various alcohols is analyzed by chronopotentiometry at a constant current of 10 mA. The 1:1 ratio of H₂O and acetonitrile was found to be optimal as the electrolyte medium. Various alcohols are effectively oxidized in a controlled manner, followed by subsequent cyclisation with various aromatic diamines in a one-pot method to synthesize N-heterocycle benzimidazole with excellent yields. The material showed excellent recyclability over 5 cycles, with minimal loss in yield and TOFs. The morphological characterization, such as PXRD, FTIR, FESEM and HRTEM, revealed that the material is stable on the electrode surface. Further, during bulk electrocatalysis, the electrocatalyst displayed excellent conversion. This approach provides superior control over catalyst properties and enables easier regeneration than in-situ methods, advancing electrosynthesis and paving the way for broader adoption in research and industrial contexts.

Comparative Adsorption Behaviour of Hazardous Dyes with Different Molecular Weights Using Hen Feathers

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The release of synthetic dyes into water bodies has become a serious environmental problem due to their toxic nature and resistance to degradation. Developing economical and sustainable methods for dye removal is therefore essential. In this study, a comparative investigation was carried out to evaluate the adsorption of three hazardous dyes – Metanil Yellow, Crystal Violet, and Aniline Blue – using Hen Feathers as a biosorbent.

Hen Feathers are a keratin-rich poultry waste material and were used without changing preparation conditions in any of the experiments to ensure a fair comparison. The selected dyes differ significantly in molecular weight and structural complexity. Adsorption performance was examined through studies on pH, contact time, adsorption equilibrium, kinetics, and thermodynamic parameters.

The results showed that dye removal efficiency is strongly affected by molecular size, with Metanil Yellow showing the highest adsorption, followed by Crystal Violet and Aniline Blue. The equilibrium adsorption data showed the best fit with the Langmuir isotherm model. However, the good agreement observed with the Freundlich and Dubinin–Radushkevich models for all three dye–adsorbent systems suggests surface heterogeneity and variation in adsorption energy. Aniline Blue displayed distinct adsorption behavior, primarily governed by surface interactions and energy distribution, while adsorption kinetics followed the pseudo–second–order model. Thermodynamic analysis confirmed that the adsorption process was spontaneous and endothermic. This study highlights the importance of dye molecular characteristics in adsorption behavior and demonstrates the potential of Hen Feathers as a low–cost and environmentally friendly adsorbent for wastewater treatment.

Substrate NOBINAc Ligand Affinity for Pd(II)-Catalyzed Enantioselective C-H Activation over Reactive β -C-H Bond in Ferrocenyl Amines

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Ferrocenylamines as a directing group for C-H activation have limitations as they are prone to undergo oxidation, allylic deamination, and α -hydride elimination. The fundamental challenge observed here is the competition between the desired C-H activation versus the vulnerable α -C-H bond activation of amines and fine-tuning of the suitable oxidant which avoids the oxidation of α -C-H bond and ferrocene. Herein, a potential of axially chiral NOBINAc ligand is revealed to implement the enantioselective Pd(II)-catalyzed C-H activation process of ferrocenyl amines. Mechanistically, an affinity between the NOBINAc ligand and sulfonate group of amine facilitated by Cs⁺ cation plays an impressive role in the desired reaction outcome via an enhanced substrate ligand affinity. This approach resulted in a Pd-catalyzed enantioselective C-H activation, first intermolecular annulation, and alkenylation of ferrocenyl amines with allenes and olefins, leading to ferrocene fused tetrahydropyridines and alkenylated ferrocenyl amines with up to 70% yields and 99:1 er.

Palladium Adorned on Reduced Graphene-poly (3, 4-ethylenedioxythiophene) for the Efficient Electro-catalytic Reduction of Hydrogen Peroxide Mediated Label Free Immunosensing of *Bacillus anthracis*; A Causative Agent of Disease Anthrax

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In this study, we are leveraging the superior conductivity of reduced graphene oxide (rGO), the electrical conductivity of poly (3,4-ethylenedioxythiophene) (PEDOT), and the catalytic properties of palladium (Pd). Reduced graphene oxide (rGO) layered with poly (3,4-ethylenedioxythiophene) (PEDOT) and decorated with palladium (rGO/PEDOT/Pd) nanocatalysts. In this study, we synthesized reduced graphene oxide (rGO) nanosheets and chemically incorporated poly (3,4-ethylenedioxythiophene) (PEDOT) and reduction of Pd salt on the surface of rGO/PEDOT. The synthesized nanocomposite was explored as label-free electrochemical immunosensor for the detection of the *B. anthracis* surface array protein antigen (Sap antigen).

Further, as synthesized nanocatalyst structure was characterized by XPS, XRD, Zeta-potential analysis, electrochemical impedance spectroscopy (EIS), and cyclic voltammetry (CV). The rGO/PEDOT/Pd nanocomposite shows sound catalytic reduction of H₂O₂, and this property was explored for detection. As synthesized rGO/PEDOT/Pd nanocomposite was used as a transduction material to amplify the electrochemical signal at the working electrode of a screen-printed electrode (SPE). The mouse anti-*B.anthraxis* Sap antibody (M α -*B.anthraxis* Sap antibody) antibody was immobilized onto the surface of rGO/PEDOT/Pd, as the nanocomposite has good biocompatibility, exceptional electrocatalytic activity, and a higher surface area; it holds the M α -*B.anthraxis* Sap antibody.

Under the optimized conditions, the label-free immunosensor, as developed, demonstrates a good working range from 1 ng/mL to 100 ng/mL and a minimum detection limit of 0.5 ng/mL for *B. anthracis* Sap antigen. The rGO/PEDOT/Pd can be explored for the rapid and sensitive detection of other biological warfare agents and their markers in different matrices.

A Hydroxy-Palmitic Acid-Functionalized Mechanoresponsive Hydrogel Offers a Sustainable Solution for the Selective Capture of Hydrogen Halides and Toxic Heavy Metals through Stimuli- Responsive Syneresis

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In an effort to discover a dual-functional and eco-friendly platform to address the challenges of halide entrapment and removal of toxic metal ions from wastewater concurrently, this work delineates a novel approach of fishing out a potential weapon compound I from a pool of three designed constructs by harnessing the concept of hydrophobic orchestration. The growing environmental concern associated with corrosive hydrogen halides and persistent heavy metal contaminants necessitates multifunctional systems capable of addressing both issues simultaneously using a single material platform.

We propose that the chloride–palmitic acid derivative, formed through nucleophilic substitution of the alcoholic hydroxy group of palmitic acid under experimental conditions, plays a crucial role in driving molecular self-assembly, ultimately leading to supramolecular hydrogel formation and selective halide entrapment. A series of amphiphilic peptide derivatives appended with 16-hydroxypalmitic acid were synthesized and thoroughly characterized using spectroscopic, microscopic, and rheological techniques. Selective hydrogelation was achieved in the presence of hydrogen halides in both liquid and vapor phases, and the mechanoresponsive nature of the hydrogel was systematically investigated. Furthermore, the interaction of the halide-entrapped hydrogel with Pb^{2+} and Cd^{2+} ions was examined to evaluate its potential in heavy metal remediation.

The resulting chloride–palmitic acid derivative undergoes heavy metal ion ($\text{Pb}^{2+}/\text{Cd}^{2+}$)-induced syneresis, likely driven by enhanced hydrophobicity and metal–ligand complex formation, as supported by extensive experimental evidence. This metal-triggered contraction facilitates efficient expulsion of water while retaining metal ions within the gel matrix, leading to exceptionally high removal efficiencies. Importantly, the hydrogel retains its structural integrity and functional performance over up to three reuse cycles. This dual-responsive behavior of compound I highlights its promise as a sustainable, reusable, and effective strategy for environmental management, offering a rare single-material solution for simultaneous halide capture and toxic heavy metal remediation.

Scalable Asymmetric Electrolyte with Engineered Interfacial Layers for Dendrite-Free and High-Performance Solid-State Lithium Metal Batteries

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Conventional lithium-ion batteries are nearing energy density limits, driving interest in lithium metal batteries. However, lithium dendrite growth in liquid electrolytes causes serious safety risks. Solid-state lithium metal batteries offer safer, high-energy alternatives, but interfacial instability remains a challenge. The objective of this work is to design an interface-engineered, mechanically robust solid-state electrolyte to overcome these challenges and enable safe, high-performance lithium metal batteries.

An asymmetric solid-state electrolyte was developed with two functionally distinct layers: a polymer-rich layer (PVDF-HFP/PVP/LiTFSI) to ensure intimate contact at the cathode–electrolyte interface and a ceramic-rich layer incorporating $\text{LiAl}_{0.5}\text{Hf}_{1.5}(\text{PO}_4)_3$ to provide mechanical reinforcement and lithium dendrite suppression at the anode interface. The electrolyte membrane was fabricated using a scalable solution casting method.

The asymmetric solid electrolyte (ASE) exhibits a room-temperature ionic conductivity of $3.75 \times 10^{-5} \text{ S cm}^{-1}$ with a low activation energy of 0.36 eV, indicating efficient Li^+ transport across the electrolyte membrane. Linear sweep voltammetry confirms a wide electrochemical stability window up to 4.56 V. Symmetric Li||Li cells demonstrate stable lithium plating/stripping for over 1800 h with minimal polarization and a high critical current density of 0.5 mA cm^{-2} , evidencing effective dendrite suppression by the LAHP-rich layer. Full Li|ASE|LiFePO₄ cells deliver high reversible capacities, excellent rate capability, and long-term cycling stability, retaining ~97.7% capacity after 80 cycles at 0.1 C and ~93.4% after 400 cycles at 1 C, with Coulombic efficiencies exceeding 99.9%. The synergistic combination of a mechanically rigid ceramic framework and a compliant polymer phase minimize interfacial resistance while enhancing electrochemical stability, addressing key limitations of solid-state lithium-metal batteries. These results highlight ASE as a promising electrolyte design for next-generation high-energy-density and long-lifespan solid-state batteries.

Light-induced Reversible Intercluster Conversion of Ag₁₄ NCs to Ag₇ NCs: Designing Photo-switchable Materials at the Nanoscale

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Despite the remarkable progress made on intercluster conversion in atomically precise metal nanoclusters (MNCs) and their self-organization to develop microscopic molecular architecture with well-defined size and shape, achieving light-induced reversible structural transformation and the development of micro-ring self-assembly in MNCs have, so far, remained elusive.

Here, we have synthesized OMeBT-templated AgNCs using triphenylphosphine (PPh₃) as a secondary ligand, wherein NaBH₄ was used as an external reducing agent. After 11 h of the reaction, yellow-emitting Ag₇ NCs with micro ring morphology were obtained. Further, upon the introduction of Cu²⁺ ions during the synthesis of Ag₇ NCs, the reaction mixture simultaneously yields stable AgNPs and Ag₁₄NCs after the completion of the reaction.

The present investigation touches on two long-standing quests on intercluster conversion of MNCs by showcasing a new route, light-induced Particle-Assisted Reversible Interconversion (PARI) for the reversible transformation from Face Centered Cubic (FCC) Ag₁₄NCs to Ag₇NCs. Our studies reveal that the lack of plasmonic silver nanoparticles (AgNPs) in the system results in the formation of Ag₇NCs with metallic kernels having centrosymmetric crystal packing. The molecular self-organization of Ag₇NCs through various non-covalent interactions, such as C-H...O, C-H...H, and C-H...π, leads to the formation of micro-ring morphology, a unique molecular architecture in MNCs. The in situ generated AgNPs, due to the acceleration of the reaction kinetics by Cu²⁺ ions, facilitate the growth of Ag₁₄NCs with FCC metallic kernel. These two structural units of AgNCs show light-induced reversible structural transformation, which is also associated with the reversible tuning of their spectroscopic and morphological signatures. This PARI-guided interconversion strategy put forward a most appropriate example of a structure–property relationship in MNCs.

Molecular Recognition of Fullerenes for Efficient Separation: A Step Toward Next-Generation Electronics and Solar Energy Devices

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Porphyrins and fullerenes are two important classes of molecules with wide relevance in natural systems and modern technology. Porphyrins form the core of essential biological molecules such as hemoglobin and chlorophyll, while fullerenes are carbon-based nanomaterials used in electronics, energy conversion, and biomedical research.^{1a} Despite their importance, selectively recognizing and separating different fullerenes remains challenging due to their similar sizes and weak intermolecular interactions.^{1b} In particular, C₇₀ exhibits enhanced anisotropy and superior optoelectronic properties compared to C₆₀, yet effective molecular systems capable of discriminating between them are limited. This work addresses this challenge through the design of a structurally rigid porphyrin-carbazole cavitand capable of selectively recognizing C₇₀.^{1c}

The porphyrin-carbazole cavitand was synthesized using a modular strategy combining porphyrin macrocyclization with rigid carbazole-based spacers to impose strict cavity preorganization. Structural integrity and rigidity were confirmed using NMR spectroscopy, high-resolution mass spectrometry, and single-crystal X-ray diffraction. Host-guest interactions with C₆₀ and C₇₀ were investigated using UV-visible absorption and steady-state fluorescence titrations, and binding constants were determined through nonlinear regression analysis.

The cavitand exhibits pronounced selectivity toward C₇₀ despite possessing a smaller cavity. In this system, the binding ability is governed primarily by favourable van der Waals interactions and the residual flexibility of the host framework, rather than by the volume or geometry of the cavity alone. This counterintuitive behaviour highlights the importance of weak intermolecular forces and host adaptability in fullerene recognition. The findings provide useful design guidelines for selective fullerene separation and the development of advanced functional materials relevant to energy, electronics, and nanotechnology.

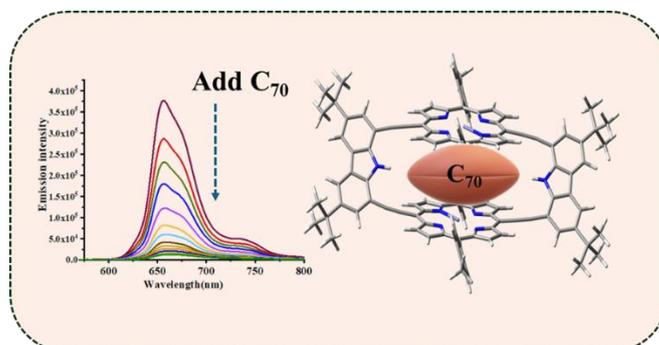


Figure 1. Selective Encapsulation of Fullerene

Quinolinium-based Fluorescent Probe for Sensing Mitochondrial Microviscosity

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Mitochondrial health reflects the ability of the organelle to maintain structural integrity, sustain efficient energy production. A healthy mitochondrial state entails effective regulation of oxidative stress related damage to cellular components, promoting overall cellular homeostasis. Any subtle irregularities in the mitochondrial microenvironment can signal the onset of a series of adverse biochemical events.

We have engineered a quinoline-based fluorescent molecular rotor (*E*)-4-(4-(diethylamino)styryl)-1-methylquinolinium iodide (NQR) to study the intricate dynamic variations in mitochondrial microenvironment. Our dye NQR is architected with a donor secondary amino group and methylated quinolinium as acceptor via extended π -conjugation to obtain far-red emission. After the spectroscopic studies we then moved to cellular studies to find out the localisation of the dye into the cellular components.

The literature study has led us to find a gap where a single dye could detect viscosity changes as well as morphological changes in mitochondria. The positive charge in the quinoline moiety of the molecule, NQR localises in mitochondria driven by the intrinsic lipophilicity of the mitochondria. After events of photophysical and microscopic studies we found out that our hypothesis has come to reality, NQR senses viscosity changes alongside stains mitochondria aiding to detect changes in mitochondrial shape and size. NQR is a dark violet solid, has proven useful as red emitting indicator and a fluorescent tag.

An Eco-friendly and Greener Approach for Controlling Acidic Corrosion on Copper Using Plant Products

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Corrosion is a major global environmental challenge that causes significant economic loss, safety risks, and material conservation issues worldwide. About 3-4% of the global gross domestic product (GDP) is lost due to the need to replace and maintain corroded metals. Plant-based corrosion inhibitors offer an affordable, biodegradable, and non-toxic alternative to prevent metal corrosion. The present study examines the anticorrosive potential of *Achalpaha wilkesiana* leaf extract on copper in a 1 N HCl medium. Techniques such as weight loss measurements (WL), adsorption isotherms, and surface morphology analysis via scanning electron microscopy (SEM) are used to assess the corrosion-inhibiting capacity of *Acalupha wilkesiana* leaf extract. Fourier transform infrared (FT-IR) spectroscopy confirms the presence of functional group in the leave extract. The leaves were collected from VIT Bhopal University. A Soxhlet apparatus with analytical-grade ethanol used as solvent to prepare the leaf extract. The test solution, 1 N HCl, was made by diluting Merck grade HCl of 36 % assay. The metal specimens were shaped and cut into $1.5 \times 1 \times 4.5 \text{ cm}^3$ coupons, washed, and polished using various grades of emery paper following ASTM G1 standards.

FT-IR spectroscopic results reveals the presence of multiple functional groups, conjugation, and π -electrons responsible for physical and chemical adsorption on the metal surface, contributing to high inhibition potential. Surface morphology studies reveal that a protective thin layer forms on the metal surface, reducing corrosion rates. Adsorption isotherm analysis indicates that the inhibitor follows Langmuir adsorption behaviour. The highest inhibition efficiency achieved was 90.6% (WL). The experimental results demonstrate that 800 ppm is the best concentration after 24 hours of immersion, providing the highest inhibition efficiency.

Corrosion is the natural degradation of metals resulting from interaction with the surrounding environment. It is an electrochemical process that involves the anodic metal dissolution process and cathodic reduction process with the flow of electrons through the electrolyte. Copper is the third-largest commercial metal globally, following aluminum and iron. 90% of total copper is extracted from its sulphide ores, with the remaining percentage derived from its oxide ore. Electrical wiring, pipelines, electronic components, roofing material, batteries, shipping aircraft, aerospace parts, and chemical processing equipment. Majorly, three sectors of a country are affected due to corrosion, namely the economy, public safety, and environment, making it a critical issue to study corrosion. NACE (National Association of Corrosion Engineers) states that corrosion is a major environmental and societal problem worldwide, affecting the national economy.

Corrosion inhibitors are chemical moiety which, when added in the minimum concentration minimize the rate of corrosion reaction. Corrosion inhibitors are one of the most acceptable solutions to prevent corrosion. Corrosion inhibitors are broadly categorised into synthetic corrosion inhibitors and natural corrosion inhibitors. Synthetic corrosion inhibitors are toxic, non-biodegradable, and expensive which when extended in the pipelines or water stream affects the human health, sometimes disturbing the biological processes and damaging the organ systems like kidneys and lungs permanently or temporarily.

Development and Evaluation of Multigrain-Based Edible Cutlery as a Sustainable Alternative to Single-Use Plastics: Nutritional and sensory Characterization

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The growing use of single-use plastic cutlery has become a serious environmental concern, creating an urgent need for eco-friendly alternatives to plastics. To address this issue, the present study focused on developing edible cutlery from sustainable indigenous grains. The present study aimed to develop multigrain-based edible cutlery, such as bowls, spoons, and sticks, and assess their proximate composition and sensory attributes.

A composite multigrain flour was formulated using Finger millet (ragi), Sorghum (Jowar), maize, Pearl millet (bajra), and wheat in 20, 20, 10, 30, and 20 % respectively. The multigrain flour blend was used to prepare edible bowls, spoons, and sticks using standardized methods involving dough preparation, molding, shaping, and frying. Nutritional analysis was performed to estimate the Total Energy, protein, Total Carbohydrates, crude fat, dietary fiber, and mineral content. The sensory evaluation of the edible cutlery was performed using a 9-point hedonic scale method by panel members.

The results showed that the developed multigrain cutlery had better sensory acceptability and was a nutritionally dense alternative, providing 334.82 kcal/100 g with significant levels of carbohydrates (48.23%), protein (9.6%), and fiber (3.7%). Its mineral profile includes calcium (27.2 mg) and iron (3.9 mg). The sensory scores for taste (8.2) and texture (8.1) confirmed that the multigrain blend enhanced the dining experience. Overall, the results support multigrain cutlery as a nutritious, well-accepted, and eco-friendly alternative to plastic disposables. The findings suggest that multigrain-based cutlery serves as both a functional utensil and a viable nutritional supplement, offering a dual solution to plastic waste and hidden hunger issues.

Role of Temperature in Structural Evolution of Ultrathin Cobalt Oxide Nanomeshes for Oxygen Evolution Reaction

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Due to continuous increase in global energy consumption and significant environmental issues, there is an urgent need for renewable and efficient energy conversion technology. Water electrolysis is an eco-friendly method for hydrogen synthesis, which serves as a renewable fuel. Currently, Ir- and Ru-based catalysts serve as the benchmark for the oxygen evolution reaction (OER); however, their practical use is hindered by their scarcity and elevated cost. Cobalt-based nanomaterials present interesting alternatives to noble-metal catalysts due to their low cost, durability, and high activity in alkaline solutions.

Herein, ultrathin Co_3O_4 nanomeshes have been synthesized by a temperature-dependent annealing approach. Controlled annealing facilitated in situ exfoliation and basal-plane etching, resulting in the formation of small mesopores within ultrathin nanosheets. Thorough structural, morphological, and surface characterizations were conducted utilizing PXRD, TEM, AFM, BET analysis, and XPS, while the electrochemical performance was assessed in alkaline environments.

The nanomaterials were synthesized at different temperatures. The nanomesh which was produced at 400 °C (CoNM-400) had superior OER performance, with a minimal overpotential of 308 mV at 10 mA cm^{-2} , an elevated mass activity of 396.7 A g^{-1} , and a turnover frequency of 6.15 s^{-1} . Electrochemical impedance spectroscopy demonstrated a negligible charge-transfer resistance and decreased pseudoresistance, signifying improved reaction kinetics. The remarkable catalytic activity arises from the synergistic effects of plentiful small mesopores (3–5.5 nm), a high roughness factor, an enhanced electrochemically active surface area, and oxygen vacancies that facilitate efficient electron transport and mass diffusion. Moreover, the evenly dispersed mesopores enable vertical ion diffusion and easy oxygen liberation during vigorous electrocatalysis. Consequently, CoNM-400 exhibited exceptional durability, maintaining continuous electrolysis for 10 days at 30 mA cm^{-2} without considerable performance decline. This study emphasizes the significance of temperature-regulated nanomesh engineering in the development of durable and highly efficient OER electrocatalysts for sustained water-splitting applications.

Rapid and Highly Efficient Synthesis of *O,O*-Dialkyl-*N,N*-dialkylphosphoramidates from *O,O*-Dialkylphosphites using Iodine as a Catalyst via Atherton–Todd Reaction

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Phosphoramidates constitute an important class of organophosphorus compounds with diverse applications in pharmaceuticals, agrochemicals, materials science, and the verification of chemicals related to the Chemical Weapons Convention (CWC). In verification analysis, *O,O*-dialkyl-*N,N*-dialkylphosphoramidates are required as reference chemicals for the unambiguous identification of the CWC-related chemicals. This class of chemicals is listed in Schedule 2.B.06 of the CWC. These phosphoramidates are degradation products of the highly toxic nerve agent *O*-ethyl dimethylphosphoramidocyanidate (Tabun, Schedule 1.A.02). Consequently, there is a scarcity of a rapid and efficient synthetic method for the synthesis of *O,O*-dialkyl-*N,N*-dialkylphosphoramidates during verification analysis.

The present work aims to develop a rapid, safe, and efficient synthetic methodology for the synthesis of *O,O*-dialkyl-*N,N*-dialkylphosphoramidates that overcomes the limitations associated with conventional methods, which require toxic reagents, hazardous transition metal catalysts, and harsh reaction conditions. A one-pot synthetic method was developed by reacting commercially available dialkylphosphite and secondary amines via the Atherton–Todd reaction using iodine as a catalyst. Reaction parameters such as solvent, temperature, reagent molar ratios, and reaction time were optimized for obtaining maximum yield.

The optimized synthesis method achieved an 88-95% product yield within 20 minutes at room temperature using dialkylphosphite (1 equiv.) with secondary amine (2 equiv.) and carbon tetrachloride/hexane (1:4, v/v) at room temperature, in the presence of Cs₂CO₃ (1.2 equiv.) as a base and iodine (10 mol %) as a catalyst. The desired product was isolated with a minimal workup procedure without the use of sophisticated equipment. All synthesized products were characterized by GC-MS, ³¹P NMR, and ¹H NMR techniques. The method demonstrates broad applicability, successfully synthesizing 10 different *O,O*-dialkyl-*N,N*-dialkylphosphoramidates.

Enhanced HER Performance of Mixed Phase 1T/2H-MoS₂ via Dual Metal Doped (Cu and Fe)

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Hydrogen fuel cells provide a clean energy source, but they are produced via electrochemical processes, which frequently employ pricey platinum catalyst. 2D-TMDs, such as MoS₂, provide intriguing alternatives because of their layered structure, large surface area. MoS₂ occurs in many phases (2H, 1T, 3R, and 1T/2H), with the 1T/2H phase exhibiting strong HER activity.

The dual metal doped (Cu and Fe) 1T/2H-MoS₂ nanosheets were prepared with various mole ratios (Cu: Fe = 0:0, 1:0, 1:1, 2:1, 1:2, 0:1) by using hydrothermal method. All precursors were added into the 1M N₂H₄·H₂O and then transferred into the autoclave and placed in a hot air oven at 180°C for 24 h.

The produced material (named as S1, S2, S3, S4, S5 and S6) was studied using a variety of methods, including XRD, Raman spectroscopy, HRTEM and XPS. XPS revealed the mixed phase of 1T/2H-MoS₂ along with Cu²⁺ and Fe^{2+/3+} oxidation states. FESEM analysis was used to analyze the surface morphologies, showing cauliflower and flower-like structures. Then, electrocatalytic applications for the hydrogen evolution reaction (HER) were studied. In this study, sample S3 material exhibits the greatest catalytic activity, showing a lower overpotential of -20 mV at 10 mA/cm², a Tafel slope of 40 mV/dec, a charge transfer resistance of 13.37 Ω, and a greater electrochemically active surface area of 47.25 cm², an exchange current density of 13.5 mA cm⁻² along with long-term stability in acidic conditions. Additionally, DFT revealed that dual metal dopants are enhancing HER performance if both dopants occupy the 2H phase of 1T/2H-MoS₂ and obtained Gibbs free energy ΔG_{H*} close to zero (i.e. 0.7 eV).

Investigation of XAFS at the K-edge of Metal Centers in Mononuclear and Binuclear Glycylglycine Complexes

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Mononuclear and binuclear glycylglycine (glygly) complexes [(glygly)Cu(OH₂)](1), [(glygly)Cu(ImH)](2), [(glygly)Cu-Im-Cu(glygly)]Na(3) and [(glygly)Cu-Im-Ni(glygly)]Na(4) (Im=imidazole) have been investigated by X-ray absorption fine structure (XAFS). Complexes 1 and 2 are mononuclear and 3 and 4 are imidazolate bridged homobinuclear and heterobinuclear respectively. The objective of the present work is to study the local coordination geometry and electronic nature of the metal centers.

X-ray absorption spectra at the Cu K-edge of complexes 1-4, Cu metal foil and the reference compounds CuO and Cu₂O and at the Ni K-edge of complex 4, Ni metal foil and the reference compounds NiCl₂ and NiSO₄ 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 raw X-ray absorption spectral data was processed using software *Athena*, the extended X-ray absorption fine structure (EXAFS) data was analyzed using software *Artemis* and the X-ray absorption near edge structure (XANES) spectrum using code *FEFF10*.

Crystal structure of only 3 is available and is known to be square planer at both the Cu centers. By analyzing XANES, the local structure around Cu centers in 1, 2 and 4, have been estimated to be square planar and around Ni center in 4 to be octahedral. Using the available crystal structure data of 3, two theoretical models have been generated for its two centers Cu1 and Cu2. For Ni K-edge of 4, the theoretical model has been generated using available crystal structure data of an analogous Ni complex. The theoretical models have been used for fitting the EXAFS data to obtain the geometries around metal centers which are found to be the same as estimated from XANES analysis. By performing ab-initio XANES calculations, simulated XANES spectra as well as p- and d-DOS have been obtained for the metal centers, which have been correlated with the experimentally measured spectra. Imidazolate-bridged binuclear Cu(II) glygly complexes are of interest as models for the active site of bovine erythrocyte superoxide dismutase which serves as an antioxidant and plays a critical role in the defense of cells against the toxic effects of oxygen radicals.

Acid Functionalized Bismuth Doped CeO₂ Nanoparticles as a Sustainable Catalyst for Synthesizing Spiroimidazolidine and Mechanistic Deeper Insight through *Ab Initio* Studies of Spiroimidazolidine Derivatives

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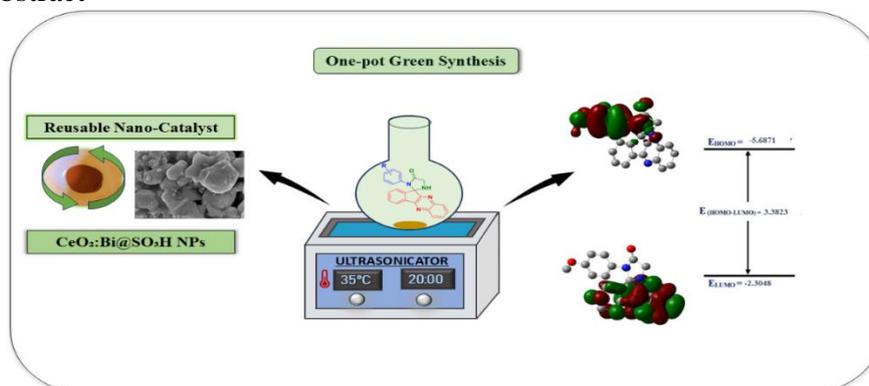
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Herein, the present work elicits the synthesis and catalytic merits of sulfonic acid functionalized bismuth-doped cerium oxide nanoparticles for the synthesis of spiro[imidazolidine-2,11'-indeno[1,2-b]quinoxalin]-5-one derivatives, followed by quantum computational studies.

The CeO₂@:Bi@SO₃H nano catalyst was prepared through an efficient combustion process followed by surface functionalization with PTSA. The spiro heterocycles were synthesized under ultrasonic irradiation and in association with prepared nano-catalyst. *Ab initio* calculations at the B3LYP/6-311G++(d,p) level of theory were performed to evaluate the mechanistic aspect in terms of chemical reactivity and the HOMO-LUMO energy gap of the synthesized spiro heterocycles.

Both the catalyst and the spiro heterocycles were characterized using a number of spectroscopic techniques, *viz.*, FT-IR, PXRD, EDX, FE-SEM, and ¹H NMR, ¹³C NMR, FT-IR, elemental analysis, respectively. The synthesis of catalyst and spiro heterocycles employs sustainable energy resources and produces no hazardous residues. Several parameters, including E-factor, Atom Economy, Process Mass Intensity, Reaction Mass Efficiency, and EcoScale Score, resulted in impressive values. The beauty of the catalyst lies in its compatibility with 3Rs (recyclable, reusable, and recoverable). These findings demonstrate adherence to the green chemistry principles. Density functional theory and frontier molecular orbital analysis indicated different stability and reactivity among the synthesized spiro heterocyclic compounds. Conclusively, the amalgamation of green synthesis with computational analysis paved the way to explore the utility of synthesized compounds in biomedical and optoelectronics applications.

Graphical Abstract



Drug-assisted White Light Generation *via* Self-assembly

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White-light generation using small organic molecules has attracted considerable interest, particularly among researchers working at the intersection of supramolecular chemistry and organic materials science. This growing attention arises from the ability of self-assembled systems to precisely control molecular organization and photophysical properties without relying on complex device fabrication. In this context, self-assembled multichromophoric materials that combine a drug molecule with a microenvironment-sensitive intramolecular charge transfer dye as an emitter provide a versatile platform for achieving tunable emission across the visible spectrum.

In the present investigation, we focused on the generation of white light through the combination of a polarity-sensitive red-emitting styryl chromone (SC) dye and a blue-emitting anticancer and psychotherapeutic drug, Norharmane (NHM), within a self-assembled micellar system. Three different surfactants were taken i.e., one cationic surfactant CTAB, one anionic surfactant SDS and a neutral surfactant TX-100 for the encapsulation of dye molecules.

A detailed spectroscopic investigation was carried out to understand the pre-micellar aggregation behavior of different surfactants possessing varying charges, using the SC dye as a sensitive probe. This approach enabled a clear understanding of how surfactant–dye interactions influence aggregation and microenvironment polarity prior to micelle formation. Encapsulation of both SC and NHM emitters inside the micellar assembly leads to a significant enhancement in their fluorescent behavior. The confinement within the micellar core of TX-100 surfactant promotes efficient spectral overlap between the blue and red emission bands, ultimately resulting in white light emission. Importantly, the generated white light exhibits excellent photostability and thermal reversibility within the self-assembled system, indicating the robustness of the micellar architecture. Overall, this investigation emphasizes the crucial role of co-assembly between the SC dye and NHM drug in achieving highly stable and efficient white-light generation using small organic molecules.

Hot-Phonon Bottleneck in CsPb(Cl/Br)₃ Perovskite Quantum Dots: Observation of Density-Independent Biphasic Carrier Cooling

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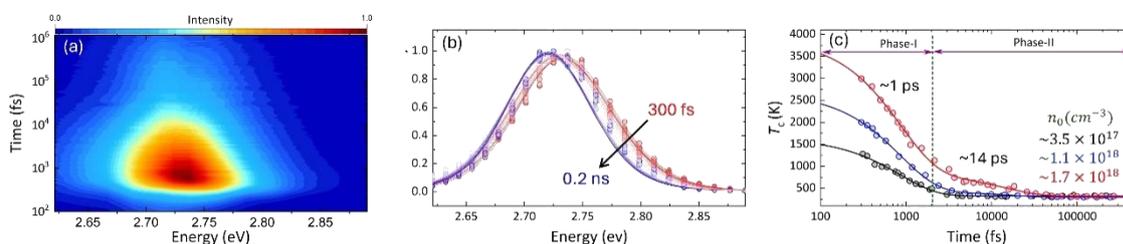
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Lead Halide Perovskite Nanocrystals have ushered in a new era in the field of photovoltaics due to their exceptional optoelectronic properties, establishing them as a new class of materials. However, understanding charge-carrier dynamics is crucial, as they can be a potential candidate for hot-carrier solar cells, enabling efficiencies exceeding 66%.¹

Here, we have used ultrafast Femtosecond Optical Gating (FOG), technique to delve into the underlying photophysics of hot-phonon bottleneck (HPB) effect, a fundamental way to prolong carrier cooling² in CsPb(Cl/Br)₃ perovskite quantum dots (PQDs). We measured Time-Resolved Emission Spectra (TRES) at different excitation fluences using FOG, and modelled with Full lineshape (FLS) model³ to extract hot-carrier dynamics.

FLS modeling of fluence-dependent hot-carrier temperature of CsPb(Cl/Br)₃ PQDs shows that hot-carrier cooling curves are composed of two distinct cooling phases. The cooling time mediated by carrier-phonon interaction (Frohlich interaction) in the 1st phase is independent of carrier density (n_0), consistent with a constant number of longitudinal-optical (LO) phonon emissions per carrier. Interestingly, the cooling time for the second phase, which is dominated by carrier reabsorption or hot-phonon bottleneck effect that occurs at higher fluences is also independent of the carrier density. Reabsorption of longitudinal optical phonons by carriers decreases the energy-loss rate and simultaneously significantly prolongs the LO phonon and hot-carrier lifetimes, enabling carriers to be extracted before they lose their excess energy as heat to the lattice. This hot-carrier extraction is beneficial from the perspective of a hot-carrier solar cell to enhance efficiency and surpass the theoretical efficiency limit of 33%.



Scheme: (a) TRES map obtained from femtosecond PL decays of PQDs (b) Full lineshape fitting (solid lines) of TRES slices (circles). (c) Hot-carrier cooling curves show the same cooling time in 1st and 2nd phases (~ 1 ps and ~ 14 ps, respectively), independent of carrier density (n_0). The solid lines show exponential fit to carrier temperatures.

Organoselenium Ligand Enabled Selective Electron Tuning for Switchable Hydrogen Evolution Reaction

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Unravelling the electronic structure of metal complexes can bring various catalytic possibilities for the hydrogen evolution reaction (HER). However, the electronic effect of metal and ligands modulating and switching the reaction centre for HER has yet to be comprehensively analysed. Herein, we report nickel selenoether electrocatalysts, which show tunable reaction centres (nickel or ligand) for HER using mild weak acetic acid in less deprotonating DMF solvent. Synthesised nickel selenoether electrocatalysts, which follow a ligand-centred pathway, demonstrated remarkably high turnover frequency (k_{obs}) up to 14000 s^{-1} with 93 % Faradaic Efficiency (F.E.). Whereas Ni-electrocatalyst having *N*-donor and selenoether ligands follows a metal-centred HER and show k_{obs} value of 2110 s^{-1} with F.E. of 98 %. A kinetic isotopic effect (KIE) study using CD_3CO_2D provides $k_H/k_D=0.49$ and 13.01 values for two types of catalysts, suggestive of metal-centred and ligand-centred catalytic behaviour, respectively. Also, EPR studies revealed nickel-centred and ligand-centred radicals in two types of Ni-electrocatalysts. Mechanistically, the EPR, CV, and DFT computation studies suggest that the electron density of the selenoether ligand plays a crucial role by acting as an electron reservoir in deciding the reaction pathways, whether hydride formation occurs at metal-centered leading to Ni–H intermediate or ligand-centred pathways for HER.

Convergence Analysis of Critical Buckling Temperature of Sandwich Plates Under Uniform Thermal Loading Using a Mathematica-Based Galerkin Formulation

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This study presents a systematic convergence analysis of the critical buckling temperature of sandwich plates subjected to uniform thermal loading using a Mathematica-based analytical framework. A refined multi-layer plate theory is employed to model the sandwich structure, incorporating transverse shear deformation and core thickness-stretching effects. The governing equations are derived symbolically and solved using the Galerkin method, with all stiffness matrices, thermal resultants, and eigenvalue problems implemented in Mathematica. Convergence characteristics are examined by progressively increasing the number of admissible trigonometric terms in the displacement field approximation, considering 7×7 , 14×14 , and 28×28 modal truncations. The evolution of the critical buckling temperature and associated response quantities is monitored to assess solution stability and convergence. Results demonstrate a clear and systematic convergence trend, allowing identification of the minimum truncation level required to obtain mode-independent predictions. The study further reveals that neglecting core compressibility leads to an overestimation of thermal buckling resistance, particularly for moderately thick sandwich plates. Parametric investigations highlight the significant influence of face-sheet stiffness and core properties on thermal stability. The proposed framework provides a reliable and computationally efficient tool for accurate thermal buckling assessment of sandwich structures.

Experimental Study of Quarry Dust as Sand Replacement and STP Water in Ultra High Performance Concrete

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Ultra-HPC (High-Performance Concrete) is an expensive, carbon-heavy material, whose high price is due to its use of expensive ingredient materials as well as high-energy production processes. This paper attempts to evaluate the feasibility of using treated sewage treatment plant (STP) water and quarry dust as partial substitutes for potable water & natural sand, respectively, in producing UHPs. The objective of this research project will be to ascertain whether these alternative materials have the mechanical strength, durability and functional performance of UHPCs. Ultimately, this research project aims to develop eco-friendly UHPCs by reducing cost and environmental impact while meeting structural performance criteria for concrete.

UHPC mixes are made with cement and silica fume as binders, with quarry dust used as a partial replacement for natural river sand at levels of 0%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 75%, and 100% by weight of fine aggregate. For each mix, 45 specimens are cast, including cubes for compressive strength, cylinders for split tensile strength, and beams for flexural strength. The performance and practicality of quarry dust-based UHPC mixes are determined by assessing their fresh and hardened properties, including workability, strength, and durability-related criteria, in line with relevant Indian standards.

Decreasing the amount of quarry dust while using an optimal mixture created denser packing of particles with increased strength for this study. Further evidence was produced to support that using treated wastewater to supply mixing water when creating UHPC has no negative impacts. Additionally, this research provides support for the use of STP WWTP and quarry waste as viable alternative materials for more sustainable and eco-friendly concrete construction while decreasing reliance on traditional materials for UHPC construction.

Comparative Study of RCC Solid and RCC Cellular Slab Supported on Ground for Vibration Control in Accelerator Facilities

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Accelerator facilities demand stringent control of vibration levels to ensure precision of synchrotron radiation. Vibration control is critical aspect in design and construction of such experimental facilities where ambient ground vibrations can affect performance of sensitive equipment having permissible limit of amplitude within μm and nm range. This study aims to design foundation systems, capable of attenuating ground vibrations by performing vibration analysis of RCC solid slab on ground and RCC cellular slab with and without infill material supported on ground.

Finite element analysis in ANSYS is performed to evaluate vibration characteristics such as natural frequency, mode shapes, amplitude through modal, harmonic and response spectrum analysis. A parametric study to investigate the effect of cellular slab configuration, subgrade properties, infill materials i.e., sand, stiff clay, geofoam, sand-rubber mix is conducted. Soil-structure interaction effect on vibration transmission is studied. Linear, elastic, homogeneous, isotropic material with damping properties is modelled followed by mesh convergence study. Finite element model is validated through analytical solution of modal analysis for solid slab. Outcomes of the study indicate that slab geometry, cellular layout, infill material, and subgrade stiffness significantly govern the dynamic behaviour of the foundation system by altering its mass, stiffness and damping properties. Cellular slab achieves substantial self-weight reduction while maintaining adequate structural stiffness, leading to material efficiency as well as vibration attenuation in the presence of optimal infill material in cells. Lighter infill material such as sand rubber mix, geofoam exhibit superior vibration attenuation due to enhanced damping, while numerous smaller cells improve stiffness and vibration response. This study will be valuable for passive vibration control and highlights optimally designed foundation system to attenuate the vibrations to permissible levels in facilities housing vibration sensitive equipment.

Time-Dependent SSSI Effects on RC Buildings During Uttarkashi Earthquake: A Comprehensive Analysis

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This study investigates the effects of structure-soil-structure interaction (SSSI) on foundation reactions and settlements of adjacent reinforced concrete buildings subjected to time history analysis using Uttarkashi earthquake data. A 3D finite element model using SAP2000 software is created for two identical three-story RC frame buildings with a 50mm seismic gap is analysed under three scenarios: Non-Interaction Analysis (NIA) with fixed base, Soil Structure Interaction (SSI) for a single building, and SSSI for adjacent buildings. The analysis evaluates structural response under both gravity (G) and combined gravity plus seismic (S) loading conditions. Results indicate that SSSI significantly alters the distribution of foundation forces, with some footings experiencing force reductions while others show notable increases compared to SSI conditions. The footings aligned with the adjacent building demonstrate the most pronounced effects. The Uttarkashi time history reveals pronounced time-dependent interaction effects, particularly during peak ground acceleration phases. These findings highlight the limitations of conventional fixed-base and even isolated SSI analyses for foundation design in densely built environments, offering crucial insights for seismic design practices in urban areas where buildings are constructed in close proximity.

Evaluation of Frame and Shell Element Modelling of Squat Shear Walls for Seismic Analysis of Buildings

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Earthquakes are natural vibrations of the Earth's crust caused by sudden release of energy. They generate ground shaking that can damage buildings, infrastructure, and the environment. However Shear walls increase the lateral strength and stiffness of a building, helping it resist earthquake-induced forces. They reduce excessive sway and storey drift, protecting both structural and non-structural elements. Because of this, buildings with properly designed shear walls perform better and suffer less damage during earthquakes.

A G+1 reinforced concrete building with squat shear walls was analysed using SAP2000 software. Three different aspect ratios ($H_w/L_w = 1.0, 0.5$ and 0.25) were considered to represent squat wall behavior. The seismic analysis was performed according to IS 1893:2016 for seismic Zones III, IV and V with hard, medium and soft soil conditions. Gravity loading and earthquake loading were applied to all models. Four commonly used modelling techniques were studied: shell elements only, shell elements with rigid beams along the wall top, shell elements with rigid beams penetrating one mesh inside the wall, and frame (mid-pier) element modelling. The effect of mesh size variation was also investigated to understand mesh sensitivity.

The analysis demonstrates that mesh size substantially affects the moment distribution and shear behavior in shell-based models, with finer meshes providing more realistic results. Incorporation of rigid beams improved overall compatibility between shell and frame modelling approaches. Frame element modelling with a rigid arm equal to one storey depth produced results closest to refined shell models, indicating its suitability for practical use. Overall, the study concludes that while all modelling approaches are suitable for linear seismic analysis.

Experimental Investigation of Entrainment and Deposition in Granular Flows Relevant to Natural Hazards

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Understanding entrainment in granular flows is critical for predicting sediment transport, runout, and deposition patterns associated with natural hazards such as debris flows, shallow landslides, and sediment-laden floods. Entrainment governs flow mobility and volume amplification, yet its dependence on grain composition, water content, and bed conditions remains insufficiently constrained, particularly in controlled experimental settings. This study investigates the influence of coarse-grained fractions and flow water content on entrainment and depositional behavior using a small-scale experimental flume, with the objective of improving links between laboratory observations and real-world sediment transport processes relevant to hazard assessment and mitigation.

A total of 32 flume experiments were conducted, systematically varying stony fractions from 0 to 20 percent and water content between 20 and 50 percent. Experiments were performed over both smooth and rough depositional beds to examine their effects on runout distance, deposition thickness, lobe formation, and channelized deposition patterns. Flow kinematics, including velocity and shear conditions, were monitored during experiments, while post-event depositional morphology was quantified using high-resolution digital elevation models generated through LiDAR scanning and direct measurements.

The results demonstrate that entrainment in granular flows is primarily governed by the combined action of basal shear and grain-scale collisional interactions. Increasing water content enhanced flow mobility and runout distances while reducing deposit thickness, indicating a transition toward more fluidized behavior. Rough beds promoted confined deposition and levee development, whereas smooth beds led to more laterally extensive deposits. Flow mobility values ranged between approximately 2.5 and 4.5, depending on stony fraction and bed roughness. Analysis of dimensionless parameters, including Bagnold and Savage numbers, confirmed the dominance of collisional stresses over frictional and viscous contributions across most experimental conditions. These findings provide experimentally grounded insights into entrainment-driven sediment transport, with direct implications for erosion control, and mitigation design.

Proposing Number of Columns Based Upon Capacities for Intze Tanks

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Depending upon the capacity; which is the volume of water that can be stored in the tank between the full supply level and the lowest supply level; number of columns to be placed is decided.

In the existing literatures; there have not been found any specific mention regarding the exact number of columns to be placed under intze tank that could have been a guidance to the designers.; though a range is specified in IS-11682:1985. In this research fifteen capacities have been considered for the overhead tank and the optimal number of columns required is derived upon through the calculation of base shear by carrying out the seismic analysis using IS-1893:2016. When there are 4, 6 or 10 number of columns, columns can only be provided at the periphery. When the columns to be provided happens to be 8, there comes two arrangements; at the periphery itself, or forming a hexagon instead of octagon and provide two columns internally.

In practicality; after going through this paper; one can directly come to know the number of columns to be as provided as per capacity with spacing between the columns included within the paper and also; one can identify the possible arrangement of columns as per the requirement. Within the existing papers; it has not been found the exact number of columns to be provided for an intze tank with a given capacity. Also in this research calculations are done for exact value of spacing between the columns and its arrangement; i.e., at the periphery or internally.

Crack Healing Performance and Cyclic Load Response of Self-Compacting Concrete with Integrated Self-Healing Mechanism

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With an increase in demand, people want concrete that lasts longer and doesn't need constant repairs, so self-healing materials are getting a lot of attention. In this study, we examine how self-compacting concrete with built-in self-healing features (Bacteria & Nutrients) responds to cracks and withstands repeated and cyclic loads. The focus is on evaluating structural integrity retention, enhancement in toughness characteristics, and under sustained and repeated cyclic loading conditions. Also, we look at how self-compacting concrete with built-in self-healing can repair cracks and handle repeated or cyclic loads.

The experimental program is such that we have designed and made self-compacting concrete with self-healing agents (Bacteria – Bacillus Subtilis & Nutrients) mixed right into the cement. In this experiment, we have made a concrete that is self-compacting concrete, which incorporates the properties of self-healing concrete into it. For this study, we have made various specimens as mortar cubes (200 no.), concrete cubes (24 no.), cylinders (24 no.), and beams (18 no.). To see how well the concrete healed, we ran mechanical tests, checked crack widths using a UPV test, and used cyclic loading to understand its cyclic behaviour. We measured the properties through mechanical testing, crack width measurements, and cyclic loading to quantify healing efficiency, strength recovery, and residual load-carrying capacity.

Self-Healing Self-Compacting Concrete stands out really well, as the results indicate the substantial crack closure and notable recovery of mechanical properties when compared to the conventional SCC. It handles repeated or cyclic loading, which enhances resistance, keeps its stiffness and durability, all while showing less damage over time (as the cracks are healing). These findings demonstrate the effectiveness of the integrated self-healing mechanism in enhancing long-term structural performance, extending service life, and promoting the sustainability of RCC structures exposed to cyclic load conditions. The importance of this type of concrete is that it is sustainable, reduces repair needs under repeated loading conditions, has superior cyclic performance and has autonomous crack closure.

Experimental Investigation of Corrosion Effects on Reinforced Concrete Structure

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Reinforced concrete is widely used in infrastructure; however, corrosion of embedded steel reinforcement remains a major durability concern worldwide. Accelerated corrosion significantly increases deterioration rates, reducing structural service life and safety. This study aims to investigate the mechanisms of accelerated corrosion in concrete rebar and evaluate its effects on structural integrity using non-destructive and electrochemical assessment techniques.

Concrete specimens were cast using ordinary Portland cement, fine and coarse aggregates, potable water, and mild steel reinforcement bars. Accelerated corrosion was induced through the voltage impressed method in the presence of a chloride solution. Experimental evaluation was carried out using rebound hammer test, ultrasonic pulse velocity (UPV) test, electrochemical corrosion testing, and half-cell potential measurements to assess concrete quality and corrosion activity.

The experimental results demonstrated a significant reduction in concrete quality due to accelerated corrosion. Rebound hammer test results showed an average rebound number of 22.95 for plain concrete, indicating fair surface hardness, whereas corrosion-affected concrete recorded an average value of 19.52, classified as poor quality. UPV measurements indicated an average velocity of 4.46 km/s for plain concrete, denoting excellent internal quality, while corrosion-induced concrete exhibited a reduced velocity of 3.88 km/s, classified as good, reflecting internal micro-cracking and loss of density. Half-cell potential test results revealed more negative potential values for corrosion specimens, confirming a high probability of active corrosion of reinforcement. Electrochemical test results indicated that the corrosion rate and percentage mass loss of steel reinforcement increased with impressed current density, validating the effectiveness of the accelerated corrosion technique. These findings highlight that corrosion adversely affects both surface hardness and internal integrity of reinforced concrete. The study emphasizes the importance of early detection of corrosion using non-destructive testing methods to assess durability, predict service life, and enhance the safety, sustainability, and economic efficiency of reinforced concrete infrastructure.

From Religious Practice to Circular Agriculture: In-Vessel Composting for Detoxification of Idol Immersion Waste

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Idol immersion represents a critical environmental challenge in India, where millions of idols enter water bodies annually, releasing toxic heavy metals (HM) that threaten aquatic ecosystems and public health. Modern idols made from plaster of Paris and metal-based pigments introduce persistent pollutants including Cu, Pb, Hg, Ni, Na, and Zn into freshwater systems, creating an urgent need for sustainable waste management solutions. This study examines in-vessel composting as an innovative bioremediation strategy to transform idol waste into safe, agriculturally valuable compost while immobilizing hazardous heavy metals.

Six insulated in-vessel composters (V1–V6) were established to co-compost green waste and food waste (4:1 ratio) with idol-derived gypsum byproduct waste at varying concentrations (5%, 10%, and 15%). Cow dung was supplemented as both additive and microbial inoculum to enhance degradation efficiency. Initial ICP-OES analysis confirmed the presence of multiple heavy metals in the gypsum byproduct and pigment waste. Post-composting samples were analyzed for heavy metal stabilization and phytotoxicity through seed germination assays using germination index (GI) values.

The composting process achieved remarkable heavy metal immobilization. Pb, Ni, and Hg were completely stabilized (100% removal), while Cu removal ranged from 84.86% to 93.04% and Zn removal from 69.37% to 80.53% in optimized treatments. Seed germination assays confirmed no phytotoxicity, with GI values exceeding 125% and reaching up to 343.61%. The gypsum–inoculum synergy effectively transformed hazardous idol waste into mature, non-toxic compost suitable for agricultural applications, demonstrating a scalable solution for sustainable religious waste valorization and environmental protection in India.

Cyclic Load Performance of Steel Mesh Integrated EPS Panels: Experimental Evaluation of Plastered and Un-plastered Surfaces

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Expanded Polystyrene (EPS) panel systems are becoming more popular as non structural wall elements due to their high strength to weight ratio, low self weight, cost efficiency, and sustainability advantages over conventional masonry walls. However, the current studies focus on the gap of experimental data on the cyclic and seismic performance of EPS panels, notably their in-plane behavior under lateral type load. The study aims to determine the load-displacement properties, energy dissipation capacity, stiffness deterioration, and failure processes of EPS panels. The purpose of the generated experimental results is to evaluate how well EPS panels can be used as non structural wall components in vulnerable areas and according to performance-based design criteria to improve safety for the occupants during an earthquake and mitigate potential economic loss.

The experimental program includes an evaluation of the performance of EPS panel systems as non-structural wall elements. As such, the research involves determining the physical characteristics of Materials as well as the details of the fabrication process for EPS panels. For this experimental program, there were a total of 18 specimens created (plaster and without-plaster), and the materials varied with respect to their height: thickness ratio. All of the specimens were tested under loads that include monotonic, cyclic, stability (lateral stability) and fatigue load tests.

Studies shows benefits of composite action and confinement of the panels in plastered EPS panels produce improved results than their unplastered counterparts. In addition to fewer cracks, sliding, and pinching, panel design affects performance significantly. By increasing the panel's thickness, it provides a stiffer and more stable panel, while a larger panel will allow for more deformation. Therefore, normalizing the test results shows that plastered specimens have a better nonlinear response, take more loading (ductility), and absorb more energy when compared to their unplastered equivalents.

Automatic Categorization of Citizen Grievances in E-Governance: A CNN–LSTM Approach for Hinglish Complaints

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The rapid expansion of e-governance platforms such as CM Helpline 181 has resulted in a significant increase in volume of citizen grievances submitted through online channels. Reported complaints are largely unstructured expressed in code-mixed language such as Hinglish and authored by users with diverse educational and literacy backgrounds. Such linguistic variability introduces complexity for conventional grievance handling mechanisms and renders manual processing inefficient and resource intensive. Effective grievance management remains a core requirement for good governance since accurate classification enables administrative authorities to prioritize issues identify recurring public concerns and initiate timely corrective action. Lack of automated analytical support restricts scalability and delays institutional response which may negatively impact citizen trust. Therefore, development of intelligent systems capable of processing large scale unstructured grievance data remains essential for strengthening digital governance infrastructures.

The present study explores automated complaint classification as a scalable and robust solution for large scale grievance management within e-governance environments. Experimental evaluation is conducted using publicly available citizen style textual data reflecting real world communication patterns. The proposed framework demonstrates strong classification performance across multiple evaluation metrics. Achieved results include accuracy of 94.44%, precision of 94.63%, recall of 94.41% and F1 score of 94.54%. Such performance confirms effectiveness of automated grievance analysis for handling linguistic diversity informal expressions and code mixed structures. Integration of automated classification mechanisms within e governance platforms can significantly improve operational efficiency transparency and responsiveness. Continuous sentiment and complaint analysis enables data driven policy evaluation service quality monitoring and proactive governance. Adoption of such intelligent systems supports timely decision making enhances citizen engagement and contributes toward development of accountable and responsive digital public service ecosystems.

ECG Signal-Based Binary Classification of Social Stress Activities and Everyday Activities Using Convolution Neural Network

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Psychological stress is a major contributor to long-term cardiovascular and mental health disorders, particularly in resource-limited regions where early diagnosis remains challenging. Distinguishing mental stress from the physiological effects of routine physical activity is essential for scalable health monitoring among vulnerable populations such as students and agricultural workers.

This study employs the GalaxyPPG dataset to develop a single-modal stress detection framework using only electrocardiogram (ECG) signals. To the best knowledge of author no classification study has been done on this dataset using CNN model, this is the first attempt to showcase this study. A deep learning-based one-dimensional convolutional neural network was designed to classify social stress and everyday activity states, with robustness ensured through five-fold cross-validation to address inter-subject variability.

Experimental results demonstrate a mean test accuracy of $85.13\% \pm 1.50\%$ and an ROC-AUC of 0.9286 ± 0.0120 . The findings confirm that ECG signals alone can reliably capture stress-specific cardiac patterns, eliminating the need for multimodal sensors and enabling practical, real-world stress monitoring applications.

Refactoring C++ Code: Manual Techniques and Automated Tooling

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Refactoring is the process of rewriting code so it's easier to maintain and safer to use, without changing what the code actually does. Developers rely on it to tackle "technical debt"—the mess that builds up in old projects. This paper looks at both tried-and-true manual methods and new automated tools for C++ refactoring, like Clang-Tidy, ReSharper C++, and IWYU (Include What You Use). Recently, AI-powered tools like MANTRA have popped up, reaching success rates above 80% in producing working, clean code. We also cover language-specific headaches, a real-life case study filled with metrics, and some thoughts on where this field is heading next. Yeah, it's a lot—but worth it.

Modern C++ projects balloon in complexity pretty darn fast. Why? Because the language packs advanced features like manual memory management, templates, and macros—and many projects last for decades. As code grows, technical debt piles up. Fowler (2018) nailed it: refactoring means "improving existing code design without changing its behavior". This is especially true for legacy C++ code cluttered with raw pointers—a tough beast to tame.

LLM-based auto-refactoring pushed big leaps recently (2024–2025). For example, MANTRA uses multi-agent AI to generate near human-quality code, scoring 82.8% success in compiling and passing tests. And get this—ChatGPT starts off identifying only about 15.6% of refactoring spots. But if you feed it clear instructions, boom, it jumps to 86.7%.

How do you know when your C++ code is a hot mess? Metrics like cyclomatic complexity (think: how many different paths your function has), maintainability index, and code churn help you measure code quality. When cyclomatic complexity per function hits above 10, you are in debug hell. Ignoring these numbers is a fast track to exploding budgets and buggy code.

Recent studies on deep learning projects tell a story—most refactoring actions involve chopping out dead code (35.16%) and renaming things to make sense (23.78%). So, no matter what, keeping code readable and clean is still king.

Embedding Privacy in Public Images for Secure AI

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The unauthorized scraping of personal images for AI training enables deepfake generation and large-scale surveillance without consent. Aligning with the Digital India and MeitY missions for responsible technology, this research engineers a proactive defense. We aim to render visual data "unlearnable" at the source, securing privacy without limiting digital engagement, as showcased in Figure 1.

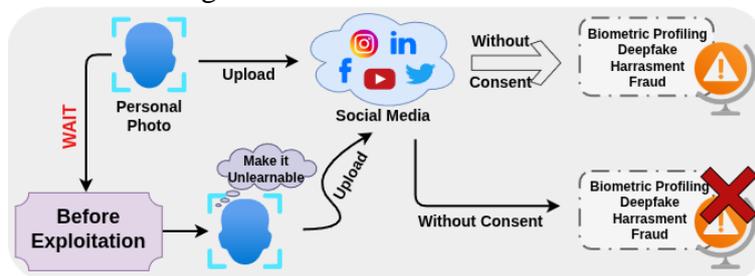


Figure 1: Safeguarding personal images from unauthorized use

We propose a Non-linear Multiplicative Perturbation (NLMP) approach that injects subtle, content-aware noise into images to interfere with representation learning in deep neural networks. The perturbations are constrained to remain imperceptible to humans and are optimized in a bi-level framework using CLIP and ResNet surrogate models. Protected image clusters are generated on standard benchmarks and evaluated across multiple target architectures for robustness, transferability, and visual quality.

Results indicate a marked drop in learning performance when images are protected with NLMP. On the Oxford-IIIT Pets dataset, ResNet-18 accuracy falls from 82.81% on clean images to 2.34% with CLIP-based NLMP, suggesting that the protected data contains little useful signal for training. Non-linear multiplicative noise also performs better than standard uniform noise (7.81% versus 14.84% accuracy), suggesting the advantage of intensity-dependent perturbations. Because the noise scales with local pixel values, the method preserves the semantic content needed for human interpretation while disturbing feature extraction in deep networks. Experiments on EfficientNet-B1 and RegNetX-1.6GF, and under differing training and testing noise distributions, show that the protection remains effective across architectures and noise conditions. These results reveal NLMP as a data-level defense that embeds privacy directly into images before sharing, enabling immediate protection against unauthorized AI exploitation across real-world platforms.

An Efficient Encoding Strategy for Lattice Protein Folding on Quantum Computers

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Protein folding has long been recognized as an NP-hard problem, presenting immense computational challenges in accurately predicting stable three-dimensional conformations of proteins. Despite substantial progress in classical algorithms, a complete and efficient solution remains elusive. Recent advances in quantum computing offer new opportunities to study the inherent complexity of protein folding with improved precision, particularly for small and simplified proteins, although scalability to large and realistic proteins remains a challenge. In this work, we developed a novel turn-based encoding framework for modeling protein folding on a cubic lattice, explicitly incorporating solvent interaction energies to capture both structural and energetic features while maintaining computational tractability.

Furthermore, we employ the Variational Quantum Eigensolver algorithm to approximate the ground state of the proposed Hamiltonian for eight different peptides of up to ten amino acids selected from the PDB, using the AerSimulator and the IBM Brisbane quantum processor. Both quantum and classical optimization techniques are utilized. For classical benchmarking, IBM CPLEX and simulated annealing are employed.

The results demonstrate that the quantum hardware produces more favorable outcomes than the simulator, indicating the potential of quantum systems to outperform classical approaches. Overall, this study establishes a foundation for quantum-enhanced protein folding simulations and paves the way for broader applications in computational biophysics. Main highlights of this work are as follows. We reduce the locality of the turn-based encoding on the cubic lattice to three, in contrast to previous formulations, thereby lowering circuit complexity. Moreover, this is the first instance in which solvent interaction energy has been integrated into a cubic-lattice encoding formulation, enabling a more realistic and physically meaningful representation of protein energetics.

ERP-Integrated Digital Ecosystem for Execution, Quality, and Invoice Management of Power Distribution Infrastructure under RDSS

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The Revamped Distribution Sector Scheme (RDSS) of the Government of India aims to modernize the power distribution sector by reducing Aggregate Technical and Commercial (AT&C) losses and improving the financial sustainability of Distribution Companies (DISCOM's) through large-scale infrastructure upgrades and digital transformation. Effective implementation of RDSS requires robust digital platforms capable of integrating project execution, quality assurance, and financial processes while interfacing with existing legacy and Enterprise Resource Planning (ERP) systems.

This paper presents the design, development, and deployment of an integrated digital ecosystem comprising a Geographical Information System (GIS), Quality Control (QC), and Common Invoice System (CIS), implemented across three state-owned DISCOM's in Madhya Pradesh. The proposed framework enables geo-enabled execution tracking, standardized quality validation, automated invoice verification, and seamless bidirectional data synchronization with ERP systems. Workflow automation aligned with departmental approval hierarchies ensures efficient processing, while real-time cross-verification of executed quantities and quality compliance enhances transparency and accountability.

The experimental results confirm that tightly coupled system integration and standardized digital workflows significantly reduce approval bottlenecks, data inconsistencies, and financial delays. The study concludes that the proposed integrated architecture provides a scalable, reliable, and governance-driven digital solution that effectively supports RDSS objectives and strengthens operational and financial efficiency in large-scale power distribution projects.

Secure Hardware IPs of Implantable Neurostimulator for Deep Brain Stimulator Medical Device

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Deep brain stimulation (DBS) procedure is a neurosurgical intervention used to treat neurological and psychiatric disorders of any person through implanted electrodes (and neurostimulator device). In the global semiconductor supply chain, ensuring authentic digital signal processing (DSP) hardware intellectual property (IP) cores in DBS system-on-chip (SoC) is vital for accurate signal processing. Compromised IP can lead to faulty signal interpretation, unstable control, and unsafe stimulation, posing serious risks to patient. The objective of this article is to design secure DSP IP cores for DBS process, addressing threats such as IP piracy and false ownership claim.

Generally, hardware IP blocks are fundamental to the operation of these electronic systems, as they significantly enhance the performance of the system. Due to the critical role of neurostimulator device in patient safety and DBS system performance, the reliability and security of these DSP-based IPs play a vital role. The proposed watermarking technique incorporates multiple layers of security during high-level synthesis (HLS) flow of IP design. It also integrates NIST standard SHAKE-256 cryptographic hash function for the first time to generate a unique, robust and non-replicable digital signature or watermark.

Embedding watermark in the IP design enhances tamper resistance and prevents unauthorized use. The proposed watermarking technique achieves higher security in terms of: (i) tamper tolerance of upto $1.34E+154$, and (ii) probability of coincidence of upto $3.34E-09$ for DSP IP application with negligible design cost overhead, as well as higher security than similar prior watermarking approaches. The presented security technique is found to be capable of successfully distinguish between authentic and pirated DSP IP versions before the integration into neurostimulator medical device. Therefore, this novel technique introduces a detective mechanism to identify and control unauthorized IPs, ensuring that only genuine DSP IP cores are integrated into the life-support DBS system.

Radar-Assisted Proactive Beam Prediction for ISAC-Enabled 6G Indoor Communications Using Temporal Convolutional Networks

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The use of mmWave bands in 6G indoor communication enables high data rates but suffers from blockage, mobility, and frequent beam misalignment. Conventional exhaustive beam training causes high latency and overhead, limiting performance in dynamic environments. Integrated Sensing and Communication (ISAC) improves reliability by jointly exploiting sensing and communication information. This work leverages radar sensing and a Temporal Convolutional Network (TCN) to capture temporal dynamics and proactively predict optimal beams, aiming to reduce training overhead while maintaining robust and accurate beam alignment.

Experiments are conducted using Scenario 42 of the real-world DeepSense-6G ISAC dataset collected in an indoor environment. Radar sensing data are processed into fixed-length temporal sequences and used as input to a Temporal Convolutional Network (TCN) with causal and dilated convolutions. The model predicts future beam indices from a predefined codebook. Performance is evaluated using time-aware 5-fold cross-validation and Top-K accuracy metrics to assess prediction accuracy, convergence, and robustness under dynamic mobility conditions.

The experimental results demonstrate that radar-assisted beam prediction using the proposed TCN framework achieves stable and accurate performance under dynamic indoor mobility conditions. Across five cross-validation folds, the model converges rapidly within 25–26 epochs and attains a mean Top-1 accuracy of 73.2%, with limited variance across folds, indicating strong generalization. High Top-K accuracies (94.6% for Top-2 and 99.9% for Top-5) confirm that the optimal beam is consistently ranked among the leading predictions, enabling efficient beam refinement with minimal training overhead. These findings highlight the effectiveness of temporal convolution in capturing mobility-induced channel evolution from radar sensing data. The results further demonstrate the practical importance of ISAC-enabled sensing for proactive beam management, offering reduced latency, improved robustness to blockage, and enhanced spectral efficiency in future 6G indoor communication systems.

A Data-Driven Participatory GIS Framework for Gender-Sensitive Urban Safety Perception Analysis

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Urban safety remains a major challenge in rapidly growing Indian cities, particularly for women, due to inadequate infrastructure and limited consideration of user perceptions in planning processes. As perceived safety majorly influences women's mobility, access to public spaces, and participation in social and economic activities, understanding these perceptions is essential for inclusive urban development. In this context, this study aims to develop a gender-sensitive, data-driven framework to analyze safety perceptions in urban streets of Bhopal for inclusive urban planning.

To address this objective, the study adopts structured computational workflow combining participatory image-based surveys with vision-based spatial analysis. Paired day–night street images from identical locations were rated on 0–10 scale by independent participants. Semantic and geometric features were extracted from images, and paired analysis isolated temporal changes in perceived safety.

The results show gender and temporal differences in urban safety perceptions across street environments. clear gender and temporal differences in urban safety perception. Women experience a significantly larger decline in perceived safety at night compared to men, particularly in streets characterized by wide road spaces and weak built-edge definition. Geometry-sensitive visual indicators were found to be more explanatory of nighttime safety loss than openness or lighting alone. The findings demonstrate that factors influencing perceived safety differ between daytime and nighttime conditions, indicating the need for time-specific urban design and intervention strategies. By identifying which visual spatial characteristics most strongly affect women's safety perception, the study provides actionable insights for gender-sensitive and context-aware urban safety planning in Indian cities.

ProtoRadNet: Prototypical Patches of Convolutional Features for Radiology Image Classification Network

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Convolutional Neural Networks have achieved success in radiology image classification, but their black-box nature limits clinical interpretability and trust. Existing prototype-based networks enhance interpretability for natural images but lack adaptation for radiology-specific challenges, including intra-class variability and subtle grayscale distinctions. This work presents ProtoRadNet, a novel patch-based prototype network specifically designed for interpretable radiology image classification, addressing both global and local interpretability through clinically meaningful prototypes.

ProtoRadNet integrates prototype learning with a ConvNeXt backbone using an ensemble loss framework comprising alignment, uniformity, prototype diversity, support vector, and cross-entropy losses. Experiments were conducted on four datasets — Brain MRI (7023 images), Chest CT (928 images), MIMIC CXR-LT (377,110 multi-label images), and Alzheimer's MRI (40,384 images) — on an NVIDIA A100 GPU using AdamW optimiser for 200 epochs with 10 prototypes per class.

ProtoRadNet achieves macro-averaged F1-scores of 92.16%, 96.14%, and 29.32% on Brain MRI, Chest CT, and MIMIC CXR-LT, respectively, surpassing all competing black-box and interpretable baselines. On Alzheimer's MRI, it achieves a competitive 93.11% with superior calibration (ECE = 4.2%). Ablation studies confirm each loss component's contribution; removing cross-entropy and prototype diversity losses reduces F1-scores by up to 10.27% and 5.56,% respectively. The model balances accuracy and efficiency with 42.3 ms inference time and 28.3M parameters. Cross-centre evaluation from MIMIC CXR-LT to NIH ChestX-ray14 yields comparable performance (F1 = 26.87%). Blinded expert validation achieved Cohen's kappa of 0.70–0.86, confirming clinical relevance. ProtoRadNet advances trustworthy AI for medical imaging by providing transparent, prototype-based decision-making without requiring pixel-level annotations, making it suitable for real-world clinical deployment where interpretability is essential.

Building More Equitable Computer Vision Systems Under Practical Constraints

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Socially sensitive domains like healthcare, security, hiring, and public services are using pretrained vision models as frozen black box feature extractors. Despite high average accuracy, these models often use spurious correlations in large-scale training data, resulting in systematic performance failures for under-represented or marginalised groups. In settings without demographic labels or model internals, such disparities may reinforce social inequalities.

PLD Debias, a black box framework, improves fairness and robustness without backbone parameters or sensitive demographic annotations. Unsupervised bias structure discovery through feature clustering is achieved by intentionally exposing latent spurious features with a lightweight rank regularised adapter. The pseudo bias labels guide supervised contrastive alignment and cluster aware adaptive margin learning to refine representations and decision boundaries while preserving the frozen backbone.

On CelebA, Waterbirds, and CMNIST benchmarks and on ResNet, CLIP, and Vision Transformers pretrained encoders, worst group accuracy improved without affecting performance. This method consistently outperforms black box methods and greatly reduces performance gaps between majority and minority groups. The inferred pseudo bias labels match ground truth bias annotations over 90% of the time, enabling near oracle fairness without sensitive attributes. Further theoretical analysis shows that the unified framework tightens worst group risk bounds under spurious correlations. PLD Debias shows that fairness can be meaningfully advanced even when models and data are constrained by real world limitations by providing an efficient, annotation-free, and privacy-conscious solution for more equitable vision systems.

HISTO-UNet: Histopathology Image Segmentation Using Topology-Aware UNet with Dual Uncertainty Quantification

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Histopathology image segmentation is vital for computational pathology, enabling automated analysis of tissue morphology for disease diagnosis. However, existing deep learning methods, despite high pixel-wise accuracy, often fail to preserve topological structures and provide reliable prediction confidence. This study aims to develop a robust framework that ensures structural integrity and uncertainty-aware segmentation.

The proposed HISTO-UNet framework is based on a UNet encoder–decoder architecture with Bayesian inference using Monte Carlo dropout. Topological consistency is enforced through medial-axis and marker-controlled constraints, while aleatoric and epistemic uncertainty are estimated using a dual-output prediction head. The model is trained with a composite loss and evaluated on public histopathology datasets.

The experimental observations indicate that HISTO-UNet consistently improves segmentation performance while preserving correct structural connectivity and shape integrity when compared with conventional deep learning models. The incorporation of topology-aware constraints effectively reduces common segmentation errors such as fragmented regions and spurious holes. Furthermore, the generated aleatoric and epistemic uncertainty maps provide meaningful insight into data ambiguity and model confidence, enabling reliable identification of uncertain predictions. These findings highlight the importance of jointly modelling structural correctness and uncertainty for dependable medical image analysis. The proposed approach is particularly important for clinical and research applications in the Indian healthcare context, as it supports safer decision-making, reduces manual verification effort, and facilitates efficient deployment of digital pathology systems in high-throughput diagnostic environments.

Efficient Redundant Frame Elimination in Videos Using Mean Similarity Analysis

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Visual-based surveillance systems produce an overwhelming amount of data, which consists of redundant information across the consecutive frames. Processing individual frames is a computationally expensive task that also decreases the efficiency of downstream video analysis tasks. Therefore, preserving relevant information while removing redundant frames has become the challenging task in video processing systems.

This study represents inter-frame similarities analysis for redundant frame reduction. The proposed technique computes the similarities among the consecutive grayscale video frames through Mean Square Error (MSE) to assess the inter-frame dissimilarity. Frames that exhibit MSE scores above the thresholds are identified as keyframes, while frames that exhibit higher visual similarity are discarded. To ensure the robustness, a systematic threshold analysis is conducted to observe frame retention across multiple threshold values. This method has a structured frame extraction and logging pipeline, which can be applied to real-world video sequences.

The experimental findings show that the introduced method efficiently minimizes the redundancy of the frame while maintaining the essential visual information. Evaluation of results indicates that selecting a proper threshold can reduce the frame redundancy by up to 62.5% without loss of relevant information. Analysis of the threshold shows the trade-off between frame reduction and information preservation, which enables real-world video-based applications (object detection, activity recognition, and embedded object analysis) to select the optimal threshold value. Due to the simplicity of this approach, it lowers the computational cost and explainability. The proposed method provides the solution for the preprocessing of video analysis tasks and can substantially enhance the efficiency of applications such as scene understanding and object detection.

An Ensemble-Based Time-Series Approach for Efficient Pricing of European Options

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As the sphere of artificial intelligence technologies moves towards more advanced deep learning models, these advanced models have become more prominent in the financial sector owing to their outstanding data modeling capacity, increased data processing ability, and better time-series pattern extraction. This article introduces a novel ensemble framework that integrates non-parametric deep learning pricing models based on NIFTY 50 European options of India.

The framework incorporates multiple deep learning models as meta-learners and base-learners, proposing a dynamic framework consisting of two ensemble models – Ens-Adaboost and Ens-CNN. In our study, we explored the feasibility of utilizing deep learning models and a time-sequencing data processing technique to price European options. To enhance the robustness of our experiments, we adopted techniques like cross-validation and statistical tests. Besides, to improve the stability and interpretability of our prediction models, we selected an interpretable statistical measure to capture correlation effects between input features and examine the deep learning models' behavior.

Owing to the empirical findings, our proposed ensemble framework, particularly the Ens-Adaboost model, demonstrated significant improvements in predicting efficiency and robustness under the dimension of moneyness, maturities, and trading dates; and outperforming baseline models by reducing prediction errors by 20%-80%. This dynamic integration methodology proposed, increases stability and enhances prediction accuracy. Options are a powerful tool in the financial world that can help manage risk, enhance returns, and improve market efficiency. In addition to offering insightful ideas for future researchers in this area, our study is a crucial resource for institutional investors, risk managers, traders, and other stakeholders.

Multi-Stream Generative Deep Learning for Fine-Grained Brain Lesion Segmentation

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Multi-Stream Generative Deep Learning for Fine-Grained Brain Lesion Segmentation leverages multiple parallel feature extraction streams and generative modeling to capture subtle lesion characteristics across diverse MRI modalities. This approach enhances boundary precision, contextual awareness, and robustness, enabling accurate delineation of small, heterogeneous lesions while improving generalization across datasets and clinical imaging variations. Accurate segmentation and functional assessment of brain lesions remain challenging in neuroimaging due to subtle, heterogeneous abnormalities in high-resolution multimodal MRI. In this light, this work propose an implementation of an end-to-end multi-stream generative DL approach for superior lesion delineation granularity, boundary detailing, and robustness in a multi-MRI modality and clinical imaging environment.

This work present PAGODA-Net (Parallel Autoencoder Gateways for Orthogonally Diffused Augmentation) as a dual-encoder generative model that can simulate 7T MRI images from standard 3T scans with accurate lesion segmentation. The model comprises parallel encoders, Information-Linking Attenuation Gateways, Residual Adaptors, a robust data pipeline with curated expert-annotated data, heavy augmentations, and wavelet-affine transformations. Training and validation were completed on multiple datasets, i.e., UPenn GBM 3T and 7T functional MRI cohorts.

Experimental results, in fact, affirm that PAGODA-Net performs better than state-of-the-art techniques by large margin. PAGODA-Net models that are trained and tested on seven Tesla images increase the Dice scores to about 0.9173 with augmentation and in the internal atlas and about 0.9535 of the same in the external primary dataset of 67 subjects with cerebral oedema and hemorrhage. The Z-test and the Chi-square analysis both confirm the significance for the proposed approach to lesion segmentation and function analysis, as year by year ultra-high-field MRI remains less accessible.

AdvPatchXAI: A Generalized, Robust, and Explainable Defense Against Physical Adversarial Patches

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Deep neural networks dominate modern computer vision but remain vulnerable against physical adversarial patches that deceive models in real-world settings. Current defenses often lack the ability to generalize against these out-of-distribution (OOD) threats or fail to align their decision-making processes with human visual perception. This study addresses these vulnerabilities by developing a defense framework that unifies high robustness with inherent model interpretability, ensuring that security measures in safety-critical applications such as autonomous vehicles, robotics, security, and other computer vision tasks do not come at the cost of transparency.

We propose AdvPatchXAI, a novel method that integrates explainability during the initial training phase rather than applying it as a post-hoc addition. The architecture utilizes a unique patch decorrelation loss designed to minimize feature redundancy while maximizing representation distinctiveness. Furthermore, the system employs self-supervised learning to identify prototypical parts, which are then mapped to specific classes via a sparse linear layer with non-negative weight constraints. This design creates a transparent scoring mechanism adaptable to diverse backbone architectures, including Convolutional Neural Networks and Vision Transformers.

Extensive evaluations indicate that the proposed system effectively aligns latent-space representations with pixel-level features, bridging the semantic disconnect observed in prior models. The method demonstrates superior generalization, successfully identifying unseen adversarial patterns even under severe environmental corruptions not encountered during training. By harmonizing machine decision-making with functional human vision properties, the framework significantly reduces false rejection rates and provides granular local explanations by highlighting relevant image prototypes. A comparative analysis against standard benchmarks confirms that this approach surpasses state-of-the-art (SOTA) techniques in both detection accuracy and explanatory power. Consequently, this research establishes that embedding interpretability directly into defense mechanisms offers a scalable solution for securing systems like autonomous vehicles and surveillance networks against evolving physical threats in unconstrained environments.

A Novel Framework for Compound Pluvial-Fluvial Flood Risk Assessment

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Flood risk in monsoon-dominated river basins is increasingly influenced by the interaction of extreme rainfall and river discharge, yet conventional flood assessments largely rely on univariate analyses that neglect such dependencies. Compound pluvial–fluvial floods, arising from simultaneous or lagged rainfall and streamflow extremes, can produce impacts far exceeding those of individual drivers. This study aims to develop and apply a robust statistical framework to characterize compound pluvial–fluvial flood behaviour and quantify their joint risk, with particular emphasis on a rainfall-dominated tropical basin where flood seasonality and hydrological response are strongly controlled by monsoon dynamics.

The proposed framework employs daily gridded rainfall and streamflow observations to identify extreme events using the block maxima method. Lag-time analysis is used to link rainfall extremes with corresponding streamflow responses, while bankfull discharge is adopted as a physically meaningful threshold to isolate actual flood events. Three rainfall–runoff extreme pairs are constructed, and their dependence is examined using correlation measures and copula-based bivariate frequency analysis. Appropriate marginal distributions and copula families are selected using information criteria, enabling estimation of joint probabilities and joint return periods under conjunctive and disjunctive flood scenarios.

Application of the framework to a monsoon-driven tropical river basin reveals pronounced spatial variability in compound flood behavior, governed by catchment scale, antecedent moisture, and hydrodynamic response. Downstream regions exhibit stronger synchronization between extreme rainfall and flood peaks, leading to substantially higher compound flood risk than upstream catchments. Copula-based joint return periods demonstrate that univariate approaches systematically underestimate flood hazard by ignoring rainfall–streamflow dependence. The results highlight the dominant role of monsoon rainfall persistence and pre-saturated conditions in amplifying compound flood extremes. The proposed framework provides a transferable, physically consistent approach to compound flood risk assessment, offering critical insights for flood forecasting, infrastructure design, and risk-informed water resources management in hydro-meteorologically similar regions.

Impact of Land Use/Land Cover Change on Sediment Connectivity and Soil Erosion in the Tawa Reservoir Catchment, Central India

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The Tawa Reservoir in Madhya Pradesh, India, designated as a Ramsar wetland, is a vital component of regional water resources and ecological sustainability. Rapid land use/land cover (LULC) changes within its catchment have the potential to alter erosion processes and sediment transfer pathways, directly affecting reservoir storage and ecosystem health. This study aims to evaluate spatio-temporal LULC changes and examine their influence on sediment connectivity and soil erosion dynamics in the Tawa reservoir catchment between 2017 and 2024.

LULC maps for 2017 and 2024 were obtained from the 30 m ESRI Global LULC dataset. Topographic parameters were derived from the 30 m SRTM digital elevation model, which was also used for watershed delineation, pour-point analysis, and stream ordering. Sediment connectivity was assessed using the SedInConnect tool to identify sediment source–pathway–sink relationships. Soil erosion was estimated for both years using the Revised Universal Soil Loss Equation (RUSLE), with rainfall erosivity, soil erodibility, slope length–steepness, cover management, and support practice factors sourced from established datasets and resampled to a common 30 m resolution.

The results indicate substantial LULC transitions, with cropland and built-up areas increasing by approximately 161 km² and 42 km², respectively, while rangelands and forest cover declined by about 214 km² and 31 km². Soil erosion severity analysis reveals a shift from low and moderate erosion classes toward high and very high erosion categories, particularly along agricultural slopes and near-channel zones. These changes have enhanced sediment connectivity, increasing sediment delivery potential to the reservoir. The study highlights emerging sediment hotspots and underscores the importance of integrated land-use planning and soil conservation measures for sustainable management of the Ramsar-listed Tawa Reservoir.

The Future of Global Ramsar Wetlands Under Intensifying Precipitation Extremes: Arid Regions as Emerging Hotspots

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Wetlands are critical ecosystems sustaining ecological balance, climate regulation, water purification, and biodiversity, yet climate-induced precipitation extremes pose growing threats to their hydrological stability worldwide. This study investigates hydroclimatic regime shifts across 2,490 Ramsar wetlands using a climate-informed framework integrating precipitation variability and extremes, assessed through a multi-model ensemble of 13 CMIP6 models for historical (1951–2024) and SSP585 future (2025–2100) periods. In arid regions, annual precipitation increased 9.3% (337.3 to 368.7 mm) while Ramsar wetlands expanded 14.5% (447 to 512 sites), reflecting spatial growth under evolving hydroclimatic regimes. Despite remaining driest, arid wetlands exhibit heightened hydrological stress with RR95 frequency rising 16.36%, R95pTOT contributions increasing 7.74% (11.21% to 12.08%), SDII rising 9.5% (2.1 to 2.3 mm/day), and Rx1 climbing 11.9% (12.6 to 14.1 mm), indicating greater event-scale intensity. Across all climate zones, wetland-year records exceeding extreme rainfall thresholds increased significantly, reaching 95% for R95pTOT in temperate zones and over 80% in arid regions, demonstrating a global shift toward clustered, intense precipitation events. The expansion of arid zone wetlands coupled with increasing extremes creates a paradoxical risk where short, intense water bursts undermine ecosystem resilience, intensify flash flooding, and disrupt fragile wetland hydrology. These findings underscore urgent needs for climate-resilient wetland management policies tailored to arid and vulnerable regions, with targeted adaptation strategies including early warning systems, sustainable land use, and nature-based solutions essential for preserving wetland integrity aligned with SDG 13 (Climate Action) and SDG 14 (Life Below Water).

Estimation of Above-Ground Biomass and Carbon Stock in Kanha Tiger Reserve, Madhya Pradesh Using GEDI LiDAR and Random Forest Modelling

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Accurate estimation of forest above-ground biomass (AGB) is critical for understanding carbon dynamics and supporting climate change mitigation strategies. This study aims to estimate and map AGB and above-ground carbon stocks in the Kanha Tiger Reserve, central India, a tropical deciduous forest landscape characterized by distinct core and buffer management zones.

GEDI spaceborne LiDAR-derived AGB (L4A) data were integrated with multisensor satellite observations using a Random Forest regression model. Predictor variables included Sentinel-2 spectral bands and vegetation indices, Sentinel-1 VH backscatter, topographic parameters derived from SRTM DEM, and precipitation. Model performance was evaluated using independent GEDI reference data.

The total above-ground biomass of Kanha Tiger Reserve was estimated at 115.92 Mt, with AGB values ranging from 11.14 to 223.47 Mg ha⁻¹, corresponding to a total above-ground carbon stock of 54.48 Mt C and carbon densities between 4.96 and 104.69 Mg C ha⁻¹. Approximately 66.9% of total biomass and carbon were concentrated in the Core zone, indicating the dominance of mature forest stands. The Random Forest model achieved moderate predictive accuracy ($R^2 = 0.47$, RMSE = 39.63 Mg ha⁻¹, MAE = 27.84 Mg ha⁻¹), with Sentinel-2 SWIR bands, vegetation indices, and topographic variables emerging as key predictors. These results revealed that integrating GEDI LiDAR with freely available satellite data and machine learning provides a scalable and cost-effective framework for forest biomass and carbon stock assessment in heterogeneous tropical forest ecosystems.

Polyphase Metamorphism in Mafic Granulite from Sandmata Complex, Aravali Craton, India: An Implication for Tectanothermal Evolution in the Paleoproterozoic Era

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The Proterozoic fold belts are of special interest from a geotectonic perspective because it is commonly believed that Proterozoic plate tectonics and plate convergence were responsible for their evolution. Significant global changes seem to have occurred towards the end of the Archean, at 2.5 Ga. One of the significant changes is the formation, stabilization, and reworking of continental areas or cratons. A detailed study of Proterozoic evolution is essential for understanding the development of high-grade metamorphic terrain, the pressure-temperature-time (P-T-t) path, and the evolution of polymetamorphism. The evolution of the fold belt with time has been recognized as an essential tool in constraining tectonic processes.

The Sandmata Complex, positioned within the Aravali-Delhi mobile belt (ADMB) in northwestern India, provides invaluable insights into the Proterozoic crustal evolution of the Indian Shield. High-grade granulite-facies characterize the region enclaves within an Archean-to-Paleoproterozoic gneissic terrane. The complex reveals a polycyclic history of metamorphism, magmatism, and tectonic exhumation. The study focuses on the Bhinai area of Rajasthan, specifically on garnet mafic granulite composed of garnet, orthopyroxene, clinopyroxene, plagioclase, hornblende, and quartz. Detailed petrographic analyses and the emergence of a multilayer corona surrounding orthopyroxene and plagioclase indicate a sophisticated P-T history.

Employing quantitative methods, including Electron Probe Micro-Analysis (EPMA) of mineral chemistry and conventional thermobarometry, we identify two distinct metamorphic phases. Advanced phase-equilibrium modeling not only reproduces the observed mineral assemblages but also defines independent P-T domains for each metamorphic event. By integrating petrographic observations, mineral chemistry, and thermodynamic modeling, this research demonstrates that the Bhinai mafic granulites underwent a complex multi-stage evolution. These findings offer crucial insights into crustal thickening and the intricate thermal history of the Sandmata Complex, underscoring its significance for understanding the region's tectono-thermal evolution.

Assessment of Soil Moisture Content Variability Using Multispectral Imagery of UAV and Landsat Derived Vegetation Indices

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Accurate assessment of soil moisture content (SMC) is critical for efficient irrigation scheduling and sustainable agricultural water management. Remote sensing-based vegetation indices provide indirect information on soil and canopy conditions, offering a non-destructive approach for monitoring moisture variability at field scale. This study evaluates the relationship between three widely used vegetation indices - Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), and Enhanced Vegetation Index (EVI) derived from unmanned aerial vehicle (UAV) and Landsat imagery, with field-measured soil moisture content. Field experiments were conducted in selected plots of the CIAE experimental farm (C3 and C4 plots), Madhya Pradesh, India, during the Rabi season (November to March). Temporal and spatial variations of vegetation indices were analysed, and their relationships with observed SMC were quantified using statistical metrics including the coefficient of determination (R^2), root mean square error (RMSE), and mean absolute error (MAE). Results indicate that NDWI exhibited higher sensitivity to soil moisture variations compared to NDVI and EVI. The findings demonstrate the potential and limitations of vegetation indices for indirect soil moisture assessment and highlight their relevance for field-scale irrigation monitoring.

Recent Decline in Groundwater Levels Across Madhya Pradesh, India (2000–2022)

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Groundwater is the primary source of irrigation and domestic water supply in Madhya Pradesh, India, where increasing water demand and climatic variability have raised concerns about long-term sustainability. Despite seasonal recharge during the southwest monsoon, several regions continue to experience groundwater stress. This study aims to analyse the spatio-temporal variability of groundwater levels, quantify long-term seasonal and annual trends, and examine the role of aquifer characteristics in governing groundwater behaviour across the state.

Monthly groundwater level data from observation wells for the period 2000–2022 were analysed and aggregated into representative seasonal conditions (January, May, August, and November) and annual means. Spatial patterns of seasonal groundwater levels were mapped, and long-term trends were evaluated using the non-parametric Mann–Kendall test and Sen’s slope estimator. Temporal variations were examined using state-scale averaged time series. Aquifer characteristics were assessed through aquifer-wise and spatial analysis of specific yield to understand differences in groundwater storage and response. Comparative trend analysis was carried out for pre-2015 and post-2015 periods to identify recent changes in groundwater dynamics.

The results reveal pronounced seasonal variability in groundwater levels, with shallow levels during the monsoon and severe depletion during the pre-monsoon period, indicating strong dependence on monsoonal recharge. Trend analysis shows widespread declining groundwater levels across most seasons and at the annual scale, with a marked acceleration in depletion after 2015. The annual rate of groundwater decline increased nearly tenfold in the post-2015 period compared to earlier years, highlighting a shift towards persistent groundwater stress. Although monsoon-season groundwater levels show partial recovery, reduced post-monsoon retention indicates that seasonal recharge is insufficient to offset increasing abstraction. Aquifer-wise analysis demonstrates that large parts of Madhya Pradesh are dominated by low-specific-yield crystalline aquifers, which exhibit limited storage capacity and rapid water-level decline. The combined interpretation of spatial patterns, temporal trends, and aquifer properties underscores that groundwater stress in Madhya Pradesh is structurally controlled by hydrogeology and amplified by recent intensification of extraction, emphasizing the need for aquifer-specific and season-sensitive groundwater management strategies.

Earth Observation and Machine Learning for Mapping Undocumented Open Dumpsites in Peri-Urban India

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Open dumping of solid waste in peri-urban regions poses serious environmental and atmospheric concerns by modifying land surface properties, generating localized thermal anomalies, and degrading vegetation cover. Rapid urban expansion and limited ground-based inventories hinder timely identification of such dumpsites by local authorities. The present study aims to develop an Earth observation-based framework for systematic detection of undocumented open dumpsites using satellite data and machine learning techniques. The objective is to integrate spectral and thermal indicators to understand land-atmosphere interactions associated with waste accumulation and to support sustainable environmental monitoring in peri-urban settings of Madhya Pradesh, India.

Sentinel-2 multispectral satellite images for the year 2022 were used to detect open dumpsites across selected peri-urban regions. A Random Forest (RF) machine learning classifier was implemented to identify dumpsite locations based on spectral characteristics. Ground truth data were collected for validation. Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI), and Normalized Difference Built-up Index (NDBI) were derived from satellite imagery. Logistic regression analysis was applied to evaluate the influence of these land surface indicators on the classified dumpsite features and to quantify their contribution to dumpsite detection.

The RF classification achieved an overall accuracy of 86.49%, demonstrating the robustness of machine learning for dumpsite detection using Earth observation data. Analysis revealed that identified dumpsites exhibit elevated surface temperatures ranging from 35.47 to 39.58 °C, indicating localized thermal anomalies. NDVI values (0.04–0.25) reflected vegetation stress, while NDBI values (–0.06 to 0.12) captured surface heterogeneity associated with waste accumulation. The logistic regression model achieved an overall accuracy of 88%, confirming the significance of combined thermal and spectral indicators in detecting dumpsites. Using this integrated approach, 60 previously undocumented dumpsites were identified. The study highlights the role of open dumpsites as localized anthropogenic stressors influencing land surface thermal behavior and ecosystem health. The framework offers a scalable and cost-effective tool for environmental monitoring, supporting policy-driven waste management and climate-sensitive urban planning. Future work will integrate high-resolution satellite data and field investigations to assess morphological and compositional characteristics of identified sites.

Assessment of Future Hotspots of Climate Risk Across Madhya Pradesh based on CMIP6 Climate Projections and Socio-economic-environmental Vulnerability

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Climate variability and extreme weather events are intensifying across central India, directly affecting agriculture, water resources, and public health. Madhya Pradesh, a climate-sensitive, agriculture-dominated state, has experienced erratic monsoon behaviour, rising temperatures, and frequent heatwaves over the past few decades. Despite these emerging risks, integrated assessments combining historical trends, future projections, land-use change, and socio-economic vulnerability remain limited at the state scale. This study aims to evaluate long-term changes in rainfall and temperature extremes, examine future climate scenarios, identify spatial hotspots of risk, and assess multi-hazard vulnerability to support evidence-based climate adaptation and regional planning. Daily gridded rainfall and temperature data (1951–2024) from the India Meteorological Department were used to compute climate extreme indices following the ETCCDI framework. Future projections were obtained from CMIP6 multi-model ensemble under SSP2-4.5 and SSP5-8.5 scenarios. Trend detection was performed using Modified Mann–Kendall test, Sen’s slope estimator, and Pettitt change-point analysis. GIS techniques were applied to generate spatial patterns of climate variability and to integrate socio-economic indicators, land-use information, and infrastructure datasets. A composite vulnerability framework combining hazard exposure, sensitivity, and adaptive capacity was developed at the tehsil level. Results indicate significant warming across Madhya Pradesh, driven mainly by rising minimum temperatures and increasing heat-extremes, with a sharp increase in days exceeding 40°C and a decline in cold-events. Rainfall patterns show growing variability, with shorter, more-intense rainfall-events, longer wet spells, and extended dry periods, increasing both flood and drought risks. Future projections suggest stronger warming and declining rainfall under high-emission scenarios, amplifying climate stress on water and agriculture systems. Land-use changes, particularly urban expansion and agricultural intensification, further enhance heat and flood vulnerability. Vulnerability mapping identifies central, western, and southeastern tehsils as climate-risk hotspots with limited adaptive capacity. These findings highlight the urgency of implementing climate-resilient agriculture, heat-action plans, improved water management, early warning systems, and nature-based solutions.

Design Of An FPGA-Based VME Digital Input Board for Accelerator Control Systems

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Reliable operation of particle accelerators requires continuous monitoring of distributed subsystems, including magnet power supplies, RF systems, radiation monitors, magnet control units, and safety interlocks. Digital status signals from these subsystems must be captured and analyzed in real time to ensure safe operation. Many accelerator facilities continue to rely on the VMEbus standard due to its proven reliability. Quick fault diagnosis further requires timestamped monitoring of field signals to decrease the system downtime. To address these requirements, a feature-rich FPGA-based VME digital input board has been developed for accelerator control systems.

The board provides 40 input channels organized into five galvanically isolated banks, with 24 V-compatible channels compliant with IEC 61131-2. The FPGA serves as the central control and processing unit, implementing the VME interface to communicate with the VME CPU and coordinate on-board data acquisition. Key features include programmable glitch filtering (30 μ s to 100 ms), wire-break detection, field-side power-loss detection, overtemperature and surge protection, status LEDs for visual fault detection, and a timestamping capability. Field signals are connected via DB-25 connectors and conditioned through input ICs before being transferred to the FPGA, which makes the data available to the VME CPU via the VME backplane.

Laboratory testing confirmed clean logic-level transitions and effective glitch filtering, while a Python-based GUI enabled monitoring of operational and fault conditions. Field deployment in a 10 MeV, 15 kW LINAC control system validated the board's functionality, acquiring ON/OFF, Local/Remote, and Ready status signals from steering magnet power supplies with consistent representation on the control room GUI. The FPGA-based architecture allows flexible VME interface implementation, supporting modernization of existing VME16 systems and future VME32/64 deployments. The proposed board provides a feature rich solution for accelerator digital input monitoring, with ongoing work focused on implementing the timestamping feature for improved fault diagnostics and reduced system downtime.

Hardware Implementation of High-Density Oxide-based Memory with Low Variability for Neuromorphic and Logic-in-Memory Applications

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Memristors are passive two-terminal devices that exhibit resistive switching between high and low-resistance states, typically characterized by pinched hysteresis current-voltage curves with zero-crossing behavior. Recent reports of non-zero-crossing hysteresis in electrochemical systems have revealed the influence of capacitive effects, leading to memcapacitive behavior. While memcapacitors hold significant promise for high-density data storage and neuromorphic computing, their practical implementation is constrained by pronounced cycle-to-cycle and device-to-device variability, particularly as device dimensions are scaled down.

In this work, high-density (32×32) 1 Kb memcapacitive crossbar arrays with device dimensions as small as $10 \mu\text{m} \times 10 \mu\text{m}$ are demonstrated using yttrium oxide (Y_2O_3) as the switching material. The devices are fabricated on n-type silicon substrates via a photolithography-assisted process combined with dual ion beam sputtering, enabling precise patterning of multilayer Al/ Y_2O_3 /TiN/ Y_2O_3 /Si architectures. Structural and morphological analyses are performed using X-ray diffraction, optical microscopy, and scanning electron microscopy, while electrical characteristics are evaluated using a semiconductor parameter analyzer.

The fabricated arrays exhibit low cycle-to-cycle and device-to-device variability, high on/off current ratios (>150), excellent endurance ($\sim 18,000$ cycles), long retention ($\sim 160,000$ s), and ultra-low power consumption (~ 17 pW). Electrochemical impedance spectroscopy provides further insight into the memcapacitive behavior. Additionally, the arrays demonstrate key neuromorphic functionalities through potentiation and depression. Moreover, a 16×16 array subset is employed to electrically encode random alphabet patterns and exhibit neuromorphic learning capabilities, underscoring the potential of these devices for analog and neuromorphic applications. In addition, two-input hardware logic gates are implemented using the fabricated devices, demonstrating their potential for use in logic-in-memory computing architectures.

Multi-Functional Advanced Adaptive ZA-LMS Controlled Single-Phase Grid-SPV System for EV

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The rapid reduction in the cost of solar PV modules and battery storage has promoted widespread adoption of grid-connected PV systems. However, nonlinear loads, load disturbances, and varying solar insolation degrade power quality and system stability. To address these challenges, this paper proposes a multifunctional single-phase grid-connected PV system with battery backup using a ZA-LMS adaptive control technique.

The system comprises a solar PV array, DC-link capacitor, bidirectional DC–DC converter with battery storage, voltage source converter, interfacing inductor, and a nonlinear load at the point of common coupling. A perturb-and-observe MPPT scheme is used for power extraction, while a ZA-LMS controller and hysteresis current control are implemented and validated through MATLAB-SIMULINK and laboratory-scale hardware tests.

Simulation and experimental results demonstrate stable grid voltage, near-sinusoidal grid current and effective DC-link voltage regulation under load perturbation and solar insolation variation. Compared to conventional LMS-based controllers, the ZA-LMS controller exhibits faster convergence, improved transient response, and reduced harmonic distortion. Hardware results closely match simulation outcomes, confirming practical feasibility. The system also enables bidirectional power flow, supporting grid-to-vehicle and vehicle-to-grid operation. The proposed approach enhances power quality, system reliability, and operational flexibility, making it suitable for modern grid-connected PV applications.

IoT-Enabled Soil Health Monitoring System Using Sleep–Wake Controlled Distributed Sensor Nodes

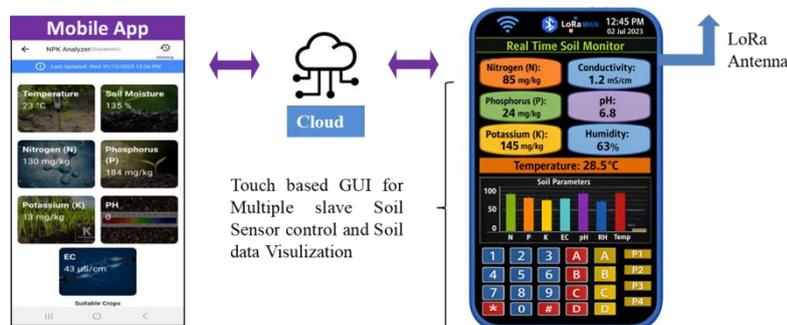
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Efficient soil health monitoring is a critical requirement for precision agriculture and sustainable crop production, particularly in the context of increasing resource constraints and climate variability. This work aims to develop an IoT-enabled soil health monitoring system capable of providing real-time, spatially distributed soil parameter measurements. The proposed system addresses the limitations of conventional manual soil testing by enabling continuous monitoring, remote accessibility, and energy-efficient operation suitable for long-term agricultural deployment.

The developed system employs multiple distributed slave sensor nodes equipped with soil moisture, temperature, pH, electrical conductivity, and macronutrient (nitrogen, phosphorus, and potassium) sensors. Each slave node is integrated with a low-power microcontroller and operates under a sleep–wake scheduling mechanism to minimize power consumption. The sensed data are periodically transmitted wirelessly to a centralized master module, which aggregates and displays the information locally while simultaneously uploading it to a cloud-based IoT platform. A mobile application interface enables real-time visualization, historical data access, and crop suitability assessment.

Experimental results demonstrate reliable multi-node communication, accurate sensing of soil parameters, and substantial power savings achieved through the sleep–wake operational strategy. The system exhibits scalability, allowing additional sensor nodes to be deployed over large agricultural fields without significant performance degradation. By providing continuous, real-time soil health insights and remote monitoring capability, the proposed platform supports optimized irrigation scheduling, precise nutrient management, and improved crop yield. The integration of energy-efficient sensing, cloud connectivity, and user-friendly mobile access makes the system a practical and cost-effective solution for smart agriculture, contributing to resource conservation and sustainable farming practices.



A Chip-Scale Reconfigurable Photonic Control Engine Based on Si-Ito Heterojunction Microring Array for Data Center and Radar Front-End Systems

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The rapid expansion of data center interconnects and radar front-end systems has created a demand for reconfigurable, energy-efficient photonic hardware capable of dynamic wavelength control. This work aims to develop a chip-scale silicon photonic microring resonator array based on a silicon-indium tin oxide (Si-ITO) heterojunction, enabling low-power, electrically programmable wavelength management for next-generation optical and microwave photonic systems.

The Si-ITO microring resonator array was designed and fabricated using CMOS-compatible silicon photonics processes. The waveguides and microring structures were patterned using maskless optical lithography (PicoMaster 100), followed by RF sputtering of ITO layer and lift-off processes. Selective wet etching of Si using tetramethylammonium hydroxide, followed by annealing, was done to form a p-Si/n-ITO heterojunction. Optoelectronic characterization was performed using a tunable laser source (Keysight K-N7778C), optical spectrum analyzer (Anritsu MS9740A-009), high-speed photodetector (ThorLabs DXM30AF) and electrical biasing using high-speed probes with source meter unit (Keithley 2614B).

The experimental results demonstrated stable and repeatable electro-optic (EO) performance of the reconfigurable microring array. Optical transmission measurements confirmed monotonic wavelength tuning under low bias, achieving an EO tuning efficiency of 0.5 nm/V. The microrings exhibited extinction ratios exceeding 25 dB, and quality factors of several thousand, indicating low-loss operation in the telecom wavelength band. A uniform free spectral range of approximately 28 nm was maintained across all microrings, ensuring single-mode operation and avoiding spectral overlap. Inter-channel crosstalk was suppressed below -20 dB, and high-speed operation supported data rates above 50 Gbps, establishing the platform as an energy-efficient photonic control engine for adaptive communication and radar front-end applications.

Non-Enzymatic CuO-WS₂ Heterostructure-based Creatinine Sensor for Point-of-Care CKD Monitoring

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Chronic Kidney Disease (CKD) is a progressive disorder associated with irreversible loss of renal function, where creatinine serves as a key biomarker for timely clinical assessment and disease staging. Existing enzymatic creatinine assays suffer from high cost, limited stability, restricting their suitability for decentralised testing. This work aims to develop a stable, smart, cost-effective, point-of-care, non-enzymatic electrochemical sensor based on a 2D WS₂/CuO hybrid nanostructure for sensitive, real-time creatinine monitoring integrated with Internet-of-Things (IoT) for CKD management.

The 2D WS₂ was synthesised via bottom-up Atmospheric Pressure Chemical Vapour Deposition (APCVD) to obtain high-quality, large-area films with good electrical conductivity. The WS₂ films were then transferred onto Ti/Pt interdigitated electrodes via wet transfer. The WS₂/CuO hybrid nanocomposite was formed by drop-casting hydrothermally synthesised CuO nanoflakes onto the WS₂-modified interdigitated electrode platform as the active sensing layer. The structural and morphological properties were systematically characterised using X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), and High-Resolution Transmission Electron Microscopy (HRTEM) to confirm phase purity, crystallinity, and hybrid formation.

The fabricated WS₂/CuO hybrid sensor exhibits enhanced electron transfer, high current response, and an enlarged electroactive surface area compared to its individual components. The sensor exhibited excellent linearity over a wide range of 5 μM to 100 mM, with a low limit of detection of 48 μM , high sensitivity of 2048 $\mu\text{A mM}^{-1} \text{cm}^{-2}$, suitable for clinical diagnosis. The device exhibits a rapid response time of 30 seconds, superior selectivity against common interferents, high reproducibility, and robust long-term stability over repeated measurements for over 90 days. Coupled with IoT-enabled data acquisition, the sensor platform offers a promising pathway towards portable, real-time creatinine monitoring for early CKD diagnosis, personalised follow-up, and improved point-of-care renal healthcare.

A Two-Stage Based Hybrid Approach for Detection and Classification of FDI Attacks and Grid Contingencies

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High reliance of smart grid on communication and information technology has made it more vulnerable to malicious cyber-attacks like false data injection (FDI). It is more common and create issues at the control center. Consequently, it can compromise security and stability of the power system, and even promote illegal benefits. Thus, accurate and efficient identification of FDI attacks is critical for the secure and reliable grid operation.

Therefore, we proposed a two-stage framework for detecting and classifying false data injection (FDI) attacks and power system events using phasor measurement units (PMUs) and supervisory control and data acquisition (SCADA) measurements. The first stage employs a Weibull distribution (WD) to identify abnormal scenarios, which calculates the shape parameter, and counts ab normal measurements for designated window. The second stage utilizes the mean and standard deviation of the shape parameters obtained from the WD output, as input for a machine learning based classification model that focuses on spatial correlations among features. Furthermore, based on the results of both stages, the proposed method classifies scenarios into three distinct categories: normal, FDI attacks, and grid events.

The proposed method is validated using SCADA and PMU data from IEEE 14 and 39-bus systems on a Real-Time Digital Simulator. Comparative analysis shows superior accuracy and lower false alarm rate (FAR) than existing approaches. It effectively detects attacks with varying intensities and occurrence probabilities. Being purely data-driven, it avoids dependency on prior system knowledge, reducing modelling errors. The decision tree (DT) model requires 110 minutes for training and only 12 seconds for testing. With an overall detection time of 461 μ s per window, it comfortably meets real-time requirements, making it highly suitable for online smart grid cybersecurity monitoring.

Design and Development of an Intelligent Temperature-Based Industrial Control System using Embedded Technology

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Temperature regulation plays a vital role in maintaining safety, productivity, and equipment reliability in industrial environments. This paper describes the development and implementation of an automated temperature control system based on embedded technology. The system continuously monitors temperature using a digital temperature sensor and controls different electrical appliances according to preset temperature limits. When the temperature drops below 40°C, a heating unit is activated. If the temperature lies between 40°C and 80°C, a fan is operated, while temperatures exceeding 80°C trigger the air conditioning unit. An Arduino-based microcontroller is used for data processing and decision-making, while relay modules provide safe switching of high-power loads. The proposed system offers a low-cost, efficient, and reliable solution suitable for industrial temperature management.

The objective of this research is to design and develop an automated temperature-based industrial control system using embedded technology. Temperature regulation is crucial in industrial environments to ensure operational safety, energy efficiency, and equipment protection. Manual control systems are often inefficient and error-prone, highlighting the need for an intelligent automated solution.

The proposed system employs a digital temperature sensor interfaced with an Arduino-based embedded controller. Real-time temperature data is continuously monitored and processed using predefined threshold values. Relay modules are used to control a heater, fan, and air conditioner. Experimental validation was carried out under varying temperature conditions to evaluate system performance.

Experimental results demonstrate that the system accurately responds to temperature variations by activating the appropriate control device. The system showed reliable performance, quick response time, and reduced energy consumption. The proposed design is cost-effective, scalable, and suitable for industrial automation applications, thereby enhancing safety, efficiency, and intelligent environmental control.

Reconfigurable Multiwavelength Nanophotonic Circuit Based on Low-Voltage Optically Readable Engineered Resistive Switches

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Optically readable nanophotonic resistive switching devices have emerged as promising building blocks for high-density non-volatile memory, reconfigurable photonic circuits, and unconventional computing platforms. In this work, we demonstrate a low-voltage reconfigurable multiwavelength nanophotonic circuit based on engineered resistive switches realized using a CMOS-compatible Ag–SiO₂–ITO structure integrated on a silicon-on-insulator platform. The device consists of a four-layer hybrid plasmonic architecture, where a thin SiO₂/ITO region is strategically positioned between a top Ag electrode and a rib-shaped p-Si waveguide, enabling strong subwavelength confinement of hybrid plasmonic modes at the telecommunication wavelength of 1550 nm.

Electrical biasing induces the formation and rupture of Ag conductive filaments within the SiO₂ region via an electrochemical metallization process, leading to pronounced modulation of optical absorption through interaction with the guided hybrid plasmonic modes. The optical states are read out directly from the transmission response, enabling robust optoelectronic switching with reduced susceptibility to electrical noise. Experimental results demonstrate a high extinction ratio of 27 dB for a compact active device of 10 μm × 500 nm operating at low voltages of ±2 V, along with fast switching speeds in the nanosecond regime.

Furthermore, the proposed architecture enables reconfigurable multiwavelength operation by integrating multiple identical nanophotonic resistive switches, 2 × 1 couplers and identical electrodes, allowing selective removal of wavelength channels without wavelength-specific device design. The engineered device exhibits excellent retention (~10⁴ seconds), high endurance over repeated switching cycles, low operating power, and scalability for dense photonic integration. These attributes make the proposed nanophotonic circuit highly suitable for applications in high-density optical memory, in-memory and neuromorphic computing, optical interconnects, programmable photonic circuits, and multiwavelength signal processing.

IoT-Enabled Automated Power Factor Correction Integrated with Smart Energy Monitoring, Conservation, and Load Optimization

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In modern industrial and commercial electrical installations, the widespread deployment of inductive loads such as motors, transformers, compressors, and welding equipment results in a degraded power factor and inefficient energy utilization. Poor power factor leads to increased line current, elevated power losses, voltage instability, reduced system capacity, and financial penalties imposed by utilities. To address these challenges, this idea presents a smart energy monitoring and load optimization system that integrates automated power factor correction with real-time energy analytics using Internet of Things (IoT) technology.

The proposed system continuously acquires voltage and current signals through precision sensing units, enabling a microcontroller-based controller to compute real-time electrical parameters including power factor, active and reactive power, and energy consumption. Based on the measured phase displacement between voltage and current waveforms, the controller dynamically determines the reactive power requirement and actuates appropriate capacitor banks via relay or solid-state switching. This closed-loop compensation strategy maintains the power factor close to unity while preventing over-compensation under fluctuating load conditions. IoT connectivity enables remote monitoring, cloud-based data logging, and real-time visualization of system parameters such as voltage, current, power factor, energy usage, and capacitor switching status. This provides actionable insights for load optimization, predictive maintenance, and energy management in smart industrial and commercial environments.

Simulation results through Proteus Design Suit and hardware model validates the effectiveness of the proposed approach, demonstrating improvement of power factor from as low as 0.50 to above 0.95 under varying load profiles. The developed system significantly reduces transmission losses, improves voltage regulation, enhances equipment lifespan, and lowers operational costs by minimizing utility penalties. Owing to its modular architecture, scalability, and minimal human intervention, the system is highly suitable for deployment in smart grids, industrial plants, and commercial buildings. Furthermore, the platform establishes a foundation for future extensions such as AI-based load forecasting, harmonic mitigation, and integration of renewable energy resources.

Preliminary Investigation on the Occurrence of Microplastics in the Sirpur Wetland: A Ramsar Site in Indore, Central India

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Microplastics are plastic particles ranging from 5 mm to 1 μm in size, originating from fragmentation of larger plastic materials through physical, chemical, or biological degradation. Due to improper waste disposal, these particles enter natural ecosystems and disrupt ecological functions. Wetlands are highly productive ecosystems with significant biodiversity and require monitoring for contaminants. This study investigates microplastic occurrence in Sirpur Wetland, a Ramsar site in Indore, Central India.

The water samples were collected in the monsoon season from five different stations within the lake. Samples were collected using a plankton net by filtering 100 liters of water and concentrating to 1 liter. The water collected in the receiver was centrifuged at 3500 rpm for 5 minutes, and the supernatant was filtered using vacuum filtration through 0.7 μm glass fiber filter paper. A saturated ZnCl_2 solution is added to the pellet for density separation and filtered for remaining microplastic particles. Organic matter present on the filter was digested with 7% NaOCl at 50°C for 24 hours, and filters were oven-dried for further analysis.

The result showed considerable microplastic contamination in the surface water of the wetland, with approximately 45 ± 1 items across five locations, which varies among stations. Microplastic sizes ranged from 10 μm to 1 mm. As far as shape is concerned, four different shapes were identified as fibers being most abundant, followed by fragments, foam, and pellets. A relatively high occurrence of microplastic fibres in the wetland environment has also been reported in other studies. Colour variations were also noted, from transparent/white being dominant, to black, blue, red, and brown. These color variations result from pigments and additives incorporated during plastic manufacturing, reflecting diverse pollution sources affecting this important wetland ecosystem.

Detecting Long-term Shifts in Rainfall Extremes across Arid and Semi-Arid Ecosystems of Western India

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Extreme rainfall events, once rare, are rising under a warming climate. These alterations in arid and semi-arid regions pose severe risks to water security, ecosystems, and livelihoods. This study analyzes the spatio-temporal variability of rainfall extremes, using daily gridded rainfall for Rajasthan and Gujarat for the period 1951–2024.

To evaluate long-term changes, the dataset was divided into three non-overlapping fixed windows: the baseline period (1951–1975), the midline period (1976–2000), and the recent period (2001–2024). Rainfall indices were computed at the grid level to represent mean, extreme, event-based, and duration-based rainfall characteristics. The percentage change in rainfall extremes for the midline and recent periods, relative to the baseline, was calculated to highlight emerging patterns. Non-parametric statistical method, specifically the Modified Mann-Kendall test, is used to analyze trends and changes in extreme rainfall across three periods. Additionally, Kernel Density Estimation was employed to examine the changes in the distribution of rainfall indices.

The results show that total annual rainfall increased, most prominently in the recent period, with higher gains across the western Rajasthan, Kachchh, and Saurashtra regions of Gujarat. Extreme rainfall events exhibit a noticeable increasing trend, accompanied by an overall rise in the frequency of moderate rainfall days across several regions. In the recent period, a reversal of the trend in most extreme rainfall indices (from decrease to increase) has been observed across the study region, compared to the midline and baseline periods. Overall, rainfall is becoming more intense, with regions in western Rajasthan and coastal Gujarat emerging as newer hotspots of rainfall extremes. These findings may provide vital insights for disaster risk reduction and climate adaptation planning.

Assessment of Pollutant-Ozone Interactions and Meteorological Influence over Industrial Regions of Madhya Pradesh using Machine Learning Approaches

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Ozone (O₃) formation and its temporal variations over industrial areas are highly impacted due to air pollutants (oxides of nitrogen and sulphur, aerosols, volatile organic compounds) and meteorological parameters (temperature, solar radiation, humidity, wind and elevation). This study used a method based on data integrating correlation analysis and machine learning to analyse the relationship between surface ozone, meteorological parameters, and air pollutants over the industrial areas of Mandideep and Pithampur of Madhya Pradesh state in India, from 2020 to 2024 using ground and satellite-based datasets.

The study pollutant data is taken from Central Pollution Control Board (CPCB) monitoring stations placed at the industrial sites and Boundary Level Height (BLH) data from ECMWF ERA5, satellite-based data. The prediction of ozone levels based on the meteorological factors, aerosols and gaseous pollutants, machine learning algorithms: Gradient Boosting Regressor (GBR) and Random Forest (RF) has been utilised. The dataset split each subset into two groups: 80% for training and 20% for testing. The present study also gives seasonal based models for summer, monsoon, and winter to see how ozone forms in different kinds of weather. The feature importance analysis looked at how much each parameter changed the amount of ozone.

The study highlights distinct spatial and seasonal variations in surface ozone over major industrial regions. Ozone exhibited a strong positive correlation with temperature and a negative correlation with NO_x and SO₂, indicating a predominantly NO_x-limited formation regime. Boundary layer height (BLH) played a key role by regulating atmospheric mixing, enhancing ozone formation during summer and suppressing it under shallow winter and monsoon conditions. Machine-learning models demonstrated robust predictive capability, with Gradient Boosting outperforming Random Forest. Model performance was highest during summer due to intensified photochemical activity and declined during the monsoon owing to increased humidity, precipitation, and reduced effective mixing heights.

River Water Quality Assessment in India: A Multi-Index and Machine Learning Approach

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River water quality in India exhibits significant spatial and seasonal variations, driven by hydrological processes and anthropogenic pressures from urbanization and industrial activities. Traditional water quality indices have limitations, necessitating comprehensive multi-index approaches for accurate assessment of India's complex river ecosystems. This study aimed to evaluate 10 major Indian rivers across three seasonal periods using multiple established WQI, assess inter-river variability through meta-analysis, and compare index stability across different modeling approaches to develop robust assessment frameworks for India's diverse aquatic environments.

Water quality data from ten major Indian rivers were analyzed across pre-monsoon, monsoon, and post-monsoon periods using three established indices Weighted Arithmetic WQI (WA-WQI), Canadian Council of Ministers of the Environment WQI (CCME-WQI), and National Sanitation Foundation WQI (NSF-WQI). Machine learning techniques, particularly Random Forest models, were employed to enhance predictive capabilities and assess index performance. A meta-analysis using Cochran's Q and I^2 statistics quantified inter-river variability and evaluated heterogeneity across river systems. A comparative analysis examined index stability, accuracy, and bias reduction across traditional and machine learning-based modeling approaches to identify optimal assessment methodologies.

Results revealed distinct seasonal patterns: monsoon periods consistently showed higher WQI values due to dilution effects, while urbanized rivers showed persistent deterioration across all seasons. Meta-analysis confirmed significant inter-river variability (Cochran's $Q = 283.77$, $I^2 = 96.8\%$), highlighting the need for context-specific assessment approaches. Among traditional indices, WA-WQI exhibited the highest variability, CCME-WQI provided conservative regulatory assessments, and NSF-WQI offered balanced evaluations with superior stability (RF CV $R^2 \approx 0.76$). Machine learning models demonstrated greater accuracy and reduced bias compared to traditional methods. These findings emphasize the critical need for multi-index approaches tailored to specific geographical contexts and the importance of incorporating emerging contaminants such as microplastics and pharmaceuticals for comprehensive water quality monitoring. This research provides valuable insights into the effective implementation of SDG 6.3.2 in India and supports evidence-based policy decisions for sustainable water resource management across diverse riverine ecosystems.

Earth Observation Based Assessment of Urban Surface Water Quality and Risk Hotspots for Decision Support in Indore, Madhya Pradesh

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Despite its designation as India's first "Water Plus" city, Indore continues to face localized challenges in urban surface water quality, particularly in lakes and river stretches influenced by mixed urban runoff. Sustaining recent urban environmental gains requires spatially consistent, timely, and scalable assessment mechanisms beyond conventional point-based monitoring. This study develops an automated, near real-time Earth observation-based framework to assess urban surface water quality and identify risk hotspots to support evidence-based decision making under AMRUT 2.0.

Multispectral satellite imagery at 10 m spatial resolution was processed using a cloud based automated workflow. Urban surface water bodies were delineated using spectral water indices and temporal compositing to quantify monthly and inter-annual changes in areal extent from 2017 to 2026. Surface water quality was estimated for all detected water bodies using validated bio-optical algorithms, including the Normalized Difference Chlorophyll Index for chlorophyll-a, red-band reflectance models for turbidity and total suspended matter, band-ratio formulations for coloured dissolved organic matter, red-edge indices for cyanobacteria abundance, and optical transparency models for Secchi disk depth. Percentile-based statistics were applied to delineate near real-time spatial risk hotspots.

Results reveal pronounced spatial heterogeneity in urban surface water quality across Indore, enabling clear identification of priority intervention zones. Major lakes such as Pipliyahana and Talawali Chandra Lane consistently exhibit eutrophic and turbid conditions, with chlorophyll-a exceeding 50 mg m^{-3} , cyanobacteria abundance above $150 \text{ cells mL}^{-1}$, turbidity greater than 25 NTU, and Secchi disk depth below 1 m during pre- and post-monsoon periods. Sirpur Tank shows moderate but recurrent nutrient stress with persistent hotspot formation across multiple years. Hotspot analysis indicates that approximately 10-15% of lake surface areas disproportionately drive overall degradation, reflecting localized pollutant loading rather than uniform deterioration. Validation against MPPCB, CPCB, and IMC records demonstrates an overall agreement exceeding 92%. The study highlights the utility of near real-time Earth observation in transitioning urban water governance from reactive assessments to targeted, spatially explicit intervention planning.

Epiphytic microbiome: An Excellent Candidate for Phylloremediation of Nickel

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Air pollution is a serious environmental threat in the current scenario. Global population is living in highly polluted air exceeding the WHO limits resulting in human ailments (WHO 2025). Urban green belt plantations, particularly those surrounding industrial clusters, serve as critical buffers against atmospheric heavy metal pollution. The microbiome in the phyllosphere of the green belt areas offers a unique, under-explored niche where epiphytic bacteria have evolved specialized mechanisms to survive and detoxify atmospheric Nickel deposition. Plant-based eco-friendly phylloremediation is an aesthetically appealing, solar energy-driven clean-up technology and conventional method which is considered as an alternative tool compared to physicochemical remediation techniques (Lee et al., 2021).

This study investigates the molecular profiling of Nickel-tolerant microbiome from the phyllosphere of plant species in the green belt areas of Bhopal City.

Leaf Samples were collected from the plants suggested by Capital Project Administration from green belt area of Bhopal City. Epiphytic bacteria were isolated by using leaf impression method and the biodiversity of epiphytic bacterial morphotypes was estimated. (Molly *et al.*, 2017). Initial screening for Ni²⁺ tolerance was performed on nutrient broth supplemented with varying concentrations of Ni²⁺. The bacterial morphotypes showing luxuriant growth and higher tolerance index were selected (Perez *et al.*, 2021). Molecular characterization was conducted through PCR amplification of the 16S rRNA gene followed by sequencing and phylogenetic analysis by Using Maximum likelihood method, Jukes-Cantor Correction method using software MEGA12 Version at one thousand bootstraps. (Ahmad *et al.*, 2020)

Molecular profiling of the Epiphytic morphotype confirmed the identity of the tolerant strain selected based on different parameters such as percentage abundance frequency, growth profile and Tolerance index of the morphotype.

The identified nickel tolerant strain *Proteus mirabilis* ATCC 29906 offer a promising, eco-friendly alternative for the phylloremediation of industrial effluents and urban atmospheric dust.

Cigarette Smoke Extract Induced Neurodegeneration and Cognitive Dysfunction in Adult Zebrafish: Neuroprotective Role of Hesperetin

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Neurodegenerative disorders remain a major global health challenge, particularly affecting the aging population, and are characterized by progressive neuronal loss and cognitive decline. Smoking is a significant risk factor associated with cardiovascular diseases, stroke, cancer, and neurobehavioral alterations. Cigarette smoke contains thousands of toxic constituents, including nicotine, acrolein, polycyclic aromatic hydrocarbons, and heavy metals, which contribute to neurological damage. Despite growing evidence linking smoking to diseases such as COPD and cancer, the mechanistic role of cigarette smoke components in accelerating neurodegenerative progression remains poorly understood. India alone accounts for nearly one million tobacco-related deaths annually, while over 1.3 billion smokers worldwide face increased fatalities, but there still lies a gap in understanding the mechanistic action that may increase the neurological risks. Plant-derived flavonoids, particularly Hesperetin, exhibit promising neuroprotective potential due to their potent antioxidant and anti-inflammatory properties, enabling the mitigation of smoke-induced molecular and cellular damage.

In this experiment, the adult zebrafish were acclimatized in the laboratory conditions and were exposed to the prepared cigarette smoke extract. Behavioural alterations were assessed through different behavioural assays to visualize anxiety-like and motor behaviour. Cigarette smoke-induced oxidative stress and redox imbalance were evaluated through biochemical assays, measuring oxidative stress parameters and antioxidant enzymes. Further, histopathological and immunofluorescent studies assess the neuronal integrity and neuroinflammation. Hesperetin was administered to evaluate its neuroprotective efficacy against CSE induced neurotoxicity.

CSE exposure exhibited impaired behaviour, indicating declined exploratory behaviour, elevated anxiety and worsened cognitive behaviour. These alterations were followed by significant neuronal degeneration in important brain areas, increased oxidative stress, and modified antioxidant enzyme activity. The results corroborate epidemiological data that link long-term smoking to a higher risk of developing neurological diseases. Notably, Hesperetin supplementation conserved neuronal architecture, restored redox equilibrium, and significantly reduced behavioural impairments induced by CSE.

Biofilm Formation and Antibiotic Resistance Patterns in Bacterial Isolates from Hospital Clinical Samples

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Biofilm formation by pathogenic bacteria is a major virulence factor contributing to chronic infections and increased antimicrobial resistance in hospital settings. The present clinical study aimed to evaluate biofilm-forming ability and antibiotic resistance patterns among bacterial isolates obtained from hospital clinical samples. A total of 60 clinical specimens, including urine, pus, wound swabs, and blood samples, were collected and processed using standard microbiological techniques. Isolates were identified by cultural, microscopic, and biochemical methods. Biofilm formation was assessed using the microtiter plate assay, and antibiotic susceptibility testing was performed using the Kirby-Bauer disc diffusion method according to CLSI guidelines. Among the isolates, *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae* were predominant. Approximately 63% of isolates demonstrated moderate to strong biofilm formation. Strong biofilm producers showed significantly higher resistance to β -lactam and cephalosporin antibiotics. The study highlights the association between biofilm formation and multidrug resistance, emphasizing the need for strict infection control practices and rational antibiotic usage in hospitals.

Medicinal Plants as Reservoirs of Pink Pigmented Facultative Methylophs: Screening & Molecular Characterization Approach

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Medicinal plants are known for their therapeutic properties and the microbes present on them are metabolically adapted to utilize methanol released by plants and produce phytohormones and siderophores, which support plant growth and health. PPFMs (Pink Pigmented Facultative Methylophs) belongs to genus *Methylobacterium*, which are abundant in nature and are found in environment. They are niche specific surviving by collecting and utilizing the single carbon source from plants such as methanol released from plant stomata.

The bacterial strains were isolated using AMS media and subjected to morphological analysis. Antioxidant activity was performed to evaluate their potential role in mitigating oxidative stress in plants. Representative cultures were selected based on phenotypic and functional characteristics for molecular characterization using 16S rDNA gene sequencing. Their phylogenetic tree was constructed and their relationship were analyzed. After isolation, a foliar spray was formulated using selected PPFM isolates supplemented with varying concentrations of methanol to assess their plant growth promoting efficacy in wheat plant. Chlorophyll content was also estimated using 80% acetone to assess their photosynthetic capacity.

The results revealed significant variability among the isolates in terms of all test. Several isolates exhibited superior plant growth promoting traits, indicating their potential application as bioinoculants in sustainable agriculture. This study highlights the multifunctional nature of methylophic bacteria and their importance in improving plants from pathogenic bacteria, their health and productivity and dependency on chemicals/ chemical fertilizers.

Physiological and Biochemical Responses of Soil Earthworms to Chronic Polyurethane Microplastics

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Microplastics (MPs) have emerged as an escalating threat to terrestrial ecosystems, with significant sequestration occurring within soil matrices. Among these, polyurethane (PU), widely used in industrial foams and coating represents a ubiquitous yet under-researched contaminant. While the deleterious effects of many MPs on Soil biota are documented, there is a critical lack of data regarding the chronic physiological and biochemical impacts of PU Microplastics on soil mesofauna. This study aimed to assess the chronic ecotoxicological implications of PU MPs on the African nightcrawler (*Eudrilus eugeniae*), a sentinel earthworm species vital for soil health and organic matter degradation. Earthworms were subjected to a 56-day chronic exposure assay across a concentration gradient of PU MPs (0, 200, 400, 600, and 800 mg/kg). This study employed a multi-tiered approach, integrating biomass monitoring, reproductive potential, histopathology analysis of the gastrointestinal tract, and a suite of biochemical assays, including Catalase (CAT), Superoxide dismutase (SOD), Reduced glutathione (GSH), and Acetylcholinesterase for neurotoxicity. While PU exposure did not result in significant mortality, no reproductive activity was observed, as evidenced by the absence of cocoon formation; it triggered a profound, dose-dependent reduction in biomass. Ingestion was confirmed as the primary exposure pathway, as *E. eugeniae* demonstrated a lack of selective avoidance. Biochemical analysis revealed significant oxidative stress and AChE inhibition, indicating systemic physiological strain and neurotoxicity. Histological findings further confirmed damage to the digestive integrity of the organisms. The study demonstrates that PU MPs disrupt metabolic and neurological homeostasis in earthworms. Given its high sensitivity and clear physiological response, *Eudrilus eugeniae* serves as an effective bioindicator for monitoring microplastic contamination and assessing the integrity of terrestrial ecosystems.

***In-Vitro* Assessment of Multifunctional PGPR Isolated from Pea Plants for Sustainable Heavy Metal Remediation and Pyrene Biodegradation**

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Soil contamination by heavy metals and polycyclic aromatic hydrocarbons poses a serious threat to food safety, soil fertility and sustainable agricultural productivity. Plant growth promoting rhizobacteria (PGPR) offer eco-friendly solutions for improving crop yield while mitigating environmental pollutants. Legume associated rhizobacteria are well known for their adaptive resilience. This study aimed to assess PGPR isolated from pea plants for heavy metal tolerance and pyrene biodegradation under *in-vitro* conditions.

A total of 20 bacterial isolates were characterized for key plant growth promoting traits including indole-3-acetic acid production, phosphate solubilization, ammonia production, siderophore production, HCN production and nitrogen fixation potential. Heavy metal tolerance was evaluated for Ni, Co, Cr and Cd at three different concentrations (0.1, 0.5 & 1%) using well diffusion method. Pyrene degradation efficiency was assessed through growth and degradation studies in pyrene amended MSM broth using spectrophotometric method. Two promising isolates were further analyzed using biochemical tests and 16S rRNA gene sequencing.

Among the screened isolates, P2B and P3A demonstrated superior multifunctional performance, exhibiting strong plant growth promoting attributes along with high tolerance to multiple heavy metals. Both isolates showed significant pyrene degradation efficiency under *in-vitro* conditions, indicating effective stress adaptation and metabolic versatility. Molecular identification revealed P2B as *Pseudomonas glycinae* and P3A as *Priestia aryabhatai*, both known for their environmental resilience. The combined expression of PGP traits, multi metal tolerance and pyrene biodegradation highlights these isolates as promising candidates and can be effectively developed as multifunctional bio-inoculants for integrated and sustainable bioremediation of contaminated agricultural soils. Future prospects include advanced molecular and omics-based investigations to decipher regulatory pathways governing metal tolerance and pyrene degradation, followed by greenhouse validation and field trials after laboratory testing to evaluate their practical applicability under natural agricultural systems.

Association of Ambient Air Pollution with Type 2 Diabetes Biomarkers in a Central Indian Population: A Pilot Study

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Ambient air pollution has been increasingly implicated in the development of metabolic disorders, including Type 2 Diabetes. However, limited data exist on pollutant exposure on risk markers in underexplored population from India.

The present study investigates the associations between geospatial ambient chronic exposures of air pollution (data collected over the course of 5 years) and type 2 diabetes biomarkers in the urban population of Bhopal, Central India.

Descriptive analysis showed consistently high concentrations of PM₁₀ and PM_{2.5}. PM₁₀ was negatively correlated with HOMA-IR and insulin, PM_{2.5} and SO₂ were negatively associated with BMI and WHtR but positively related to QUICKI, suggesting potentially paradoxical or non-linear relationships. The highest prevalence was observed at location Hoshangabad Road (66.7%), despite location MRI showing the greatest pollutant burden, indicating possible ecological-level misalignments. While existing findings suggest environmental exposures may influence metabolic risk, the present study demonstrates ecological design and aggregated data limit inference.

Foraging Strategies and Host–Kleptoparasite Interactions in the Dew-Drop Spider *Argyrodes elevatus*

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The present study was conducted in Indore, Madhya Pradesh, India, during September 2025–January 2026, aiming to observe foraging strategies employed by *A. elevatus* to avoid detection and retaliation from host spiders and to analyse host-kleptoparasite interactions during kleptoparasitic events in Dew-Drop spider.

Field observations were conducted in natural habitats near Choral Dam and at Sirpur Lake, Indore, where *Argyrodes elevatus* was recorded in webs of *Nephila pilipes*, *Argiope anasuja*, *Neoscona theisi*, *Stegodyphus sarasinorum*, and *Guizygiella* spp. Individual webs were monitored using direct observation of natural behaviour, web sampling, marking & release, and photographic documentation to record position, activity, frequency and duration of foraging behaviours. Laboratory observations were carried out for five months (Sep 2025–Jan 2026), totalling over 500 hours on ~60 individuals, using controlled conditions, behavioural assays, and food-deprivation experiments while maintaining kleptoparasites within host webs to regulate starvation.

Observations revealed that *Argyrodes elevatus* employs multiple foraging strategies, including stealing captured prey from host webs, feeding on leftover prey remains, feeding with host, live prey capture, theft of egg sacs, consuming host silk and preying on the host spider. The spider exhibits remarkable agility and timing, allowing it to exploit resources while minimising detection by the host. It employs adaptations like cryptic colouration and stealthy movements to avoid detection by the host. Host spiders displayed varying degrees of tolerance, ranging from passive indifference to aggressive display. Such interactions indicate a balance between resource exploitation and risk avoidance. These findings emphasise *A. elevatus* kleptoparasitic behaviour as an alternative feeding strategy, which minimises its energy costs associated with web construction and prey capture while influencing and affecting host foraging efficiency and reproductive success.

From Root to Remedies: Metabolomic Insight into *Glycosmis pentaphylla* for Skin Cancer Management

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Skin cancer is a significant global health concern, with ultraviolet radiation identified as a major contributing factor. The limitations of conventional chemotherapy, drug resistance and adverse side effects, have driven the search for safer, plant-derived therapeutic alternatives. *Glycosmis pentaphylla*, a medicinal plant used in traditional medicine, remains insufficiently explored for its chemical composition and activity against skin cancer. Therefore, this study aimed to investigate the phytochemical profile, antioxidant properties, and *in vitro* anticancer potential of *G. pentaphylla* root extracts against human skin cancer cell lines.

Root material was extracted using 80% methanol and aqueous solvents. Phytochemical characterization was performed using thin-layer chromatography, high-performance thin-layer chromatography, and gas chromatography–mass spectrometry. Antioxidant activity was evaluated by measuring total phenolic and flavonoid contents and using DPPH, ABTS, ferric reducing antioxidant power (FRAP), and cupric reducing antioxidant capacity (CUPRAC) assays. The antiproliferative activity of the extracts was determined using the MTT assay against A431 human epidermoid carcinoma and A435 human melanoma cell lines.

TLC and HPTLC analyses revealed multiple well-defined bands, indicating the presence of diverse classes of secondary metabolites. GC–MS profiling identified 30 phytochemicals, including alkaloids, quinoline derivatives, sterols, phenolics, and fatty acid esters, with 1-heptadecanol, 17-bromo- (39.68%) as the major constituent. The 80% methanolic extract exhibited significantly higher total phenolic and total flavonoid contents (22.45 ± 1.49 μg GAE/mg and 98.31 ± 1.21 μg RE/mg, respectively) compared to the aqueous extract and demonstrated superior antioxidant activity across all assays. The methanolic extract produced dose-dependent inhibition of A431 cell growth and demonstrated greater antiproliferative activity than the aqueous extract. Overall, these results suggest that *G. pentaphylla* root extract is a rich source of bioactive compounds with potent antioxidant and *in vitro* anticancer potential, supporting its traditional use and indicating its promise as a natural chemopreventive and therapeutic agent for skin cancer.

Water Quality Status of Satdharu Dam, Damoh (M.P.) with Special Reference to Plankton Diversity

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The present investigation was based on the study of water quality status of Satdharu dam which is situated at Damoh district of Madhya Pradesh state of India (M.P.) with special reference to Plankton diversity. Dams are constructed for effective utilization of water for irrigation, hydroelectrical power generation and flood control, storage of water for drinking purpose and suitable development of fisheries for the purpose of human food.

Water sample were collected throughout the year at interval of every month by four different sites of Satdharu dam. Then different water quality related physico- chemical parameters such as air /water temperature, pH, turbidity, Electrical Conductivity, TDS, total alkalinity/acidity/salinity/ hardness, chloride, DO, BOD, phosphate, sulphate, nitrate, ammonia, fluoride, Fe, Ca, Mg were done. For qualitative and quantitative plankton study, filtered (fresh or preserved) water samples were taken for light microscopy (with or without stain) and identified with taxonomic keys and enumerated by using Sedgewick Rafter counting chamber.

In this study Water Quality Index and correlation were done on the basis of different reading of physico- chemical parameters which were collected from all four sites on every month. Salinity, sulfate, and nitrate levels were found to be very low at all stations of the Satdharu Dam. Physical parameters such as temperature, pH, EC, and turbidity were similar across all stations. The average values of fluoride, Fe, Mg, Ca, and ammonia were also consistently varies across all stations. The lowest BOD value (0.99 mg/l) was observed at Station 1 in January, while the highest BOD value (3.96 mg/l) was recorded at Station 3, also in January. This dam contains diverse genera of phytoplankton and zooplankton. Phytoplankton includes *Cynobacteria* (blue-green algae), *Spirogyra* (water silk), moss leaf, *Microcystis*, *Oedogonium*, *Volvox* etc. and zooplankton viz., Copepods (*Cyclops*), *Daphnia*, Rotifers, different larvae of aquatic insects etc. This study helps in understanding the biodiversity of plankton communities and how they are influenced by physicochemical parameters. Furthermore, these findings will be beneficial for other biotic communities that depend on this dam.

Anthropogenic Activities as Vectors for Exotic Plant invasion in Sacred Landscapes: A Case Study of Jatashankar Dham, Chhatarpur, MP India

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Sacred landscapes such as Jatashankar Dham serve as vital repositories of biodiversity, yet increasing pilgrimage, tourism, and construction have intensified ecological stress. This study aimed to document exotic plant species, assess anthropogenic drivers of invasion, and evaluate impacts on native medicinal flora and cultural-ecological integrity.

A stratified random sampling approach was adopted across core temple, buffer, and forest zones using quadrats and transects to record species composition. Semi-structured questionnaires with 50-60 stakeholders captured perceptions of exotic spread, medicinal decline, and cultural beliefs. Data were analyzed using diversity indices and thematic coding for qualitative insights.

Result revealed Asteraceae dominance among exotics, with *Parthenium hysterophorus* and *Xanthium strumarium* highly invasive. Poaceae medicinal plant showed maximum decline, while *Plumbago zeylanica* and *Terminalia chebula* were threatened by overharvesting. Anthropogenic pressures directly drive biodiversity loss, underscoring the urgent need for integrated conservation strategies to safeguard sacred groves and native medicinal diversity.

***Lactobacillus acidophilus* Derived Metabolite Mediated Augmentation of Methylene Blue Based Photodynamic Inactivation of MRSA Planktonic Cells and Biofilms**

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Infections caused by antimicrobial drug-resistant pathogens, particularly methicillin-resistant *Staphylococcus aureus* (MRSA) are difficult to treat, necessitating various antibiotics-free approaches. While antimicrobial photodynamic therapy (aPDT) and probiotics are very emerging as promising alternatives, neither probiotic nor aPDT monotherapy can get rid of the biofilms completely, necessitating a combinatorial approach.

This study investigated sequential methylene blue-mediated antimicrobial photodynamic therapy (MB-aPDT) followed by *Lactobacillus acidophilus* derived cell-free supernatant (LA-CFS) against MRSA planktonic cells and biofilms. The antimicrobial and anti-biofilm efficacy was assessed by growth kinetic, colony-forming unit assay, flow cytometry, atomic force microscopy (AFM), and confocal laser scanning microscopy (CLSM).

Results show that LA-CFS (40 % v/v) subsequent to MB-aPDT mediated by MB (0.00005%) and red-light (~660 nm, fluence: ~9 J/cm²) resulted in significantly enhanced MRSA inactivation compared to individual treatments, as shown by growth kinetics, CFU reduction and flow cytometry measurements, with the following trend: aPDT < LA-CFS < aPDT + LA-CFS. AFM and CLSM data also show that compared to either of the monotherapies, the combination (MB-aPDT + LA-CFS) caused extensive membrane disruption and cell fragmentation. The antimicrobial activity of LA-CFS was found to be pH-labile. Notably, the combinatorial treatment exhibited enhanced efficacy in disrupting pre-formed biofilms and inhibiting biofilm initiation, and maturation. In case of preformed biofilms, biofilms the degree of damage also follows the similar trend as observed in case of suspension culture. These findings demonstrate that integrating aPDT monotherapy with postbiotics can be an innovative, next generation therapeutic strategy for complete eradication of MRSA biofilms.

Isolation, Optimization, and Carrier-Based Formulation of Potent Siderophore-Producing Rhizobacteria for Plant Growth Promotion

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Siderophore-producing rhizobacteria (SPR) enhance plant growth by improving iron bioavailability in the rhizosphere. This study aimed to isolate, optimize, and formulate potent siderophore-producing strains from agricultural soil to develop a sustainable plant growth-promoting inoculant for crops. The core objectives were to identify efficient native producers, optimize their siderophore yield, formulate a stable carrier-based bioinoculant, and evaluate its efficacy on tomato plants in a controlled pot trial.

Twenty-five bacterial isolates from maize field soil were screened for siderophore production using the chrome azurol S (CAS) assay. Two high-yielding isolates were selected, identified via 16S rDNA sequencing as *Bacillus safensis* (BMS-01) and *Bacillus tropicus* (BMS-15), and optimized for carbon/nitrogen sources, pH, and temperature. Solid peat-based bioformulations of each strain were prepared. A pot experiment with tomato plants employed three treatments: an uninoculated control, *B. safensis* bioformulation, and *B. tropicus* bioformulation. Plant growth parameters were measured after 30-45 days.

Optimization revealed maximum siderophore production (60–70% units) for both strains using sucrose and NaNO₃ at pH 8 and 28°C. In the pot trial, plants treated with each bacterial bioformulation showed significant increases in shoot length, root biomass and overall dry weight compared to controls. These findings demonstrate that the formulated *Bacillus* strains directly enhance plant vigor, likely through improved iron nutrition and associated physiological benefits. The successful development of a carrier-based formulation is a critical step toward field applicability. This work highlights the potential of these native strains as effective, sustainable bioinoculants to reduce chemical fertilizer dependency and promote crop productivity.

Comparative *In vitro* Evaluation of the Antifungal Activity of Methanolic and Ethanolic Flower Extracts of *Hibiscus rosa-sinensis* against *Aspergillus niger*

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This study aimed to evaluate and compare the *In vitro* antifungal efficacy of methanolic and ethanolic flower extracts of *Hibiscus rosa-sinensis* against *Aspergillus niger*. Medicinal plants are a promising source of bioactive compounds with antimicrobial potential, offering safer and cost-effective alternatives to synthetic drugs. The use of solvents with different polarities enables efficient extraction of diverse phytoconstituents. By comparing methanol and ethanol extracts, the study also sought to identify the most effective solvent system for extracting antifungal compounds. The findings contribute to plant-based drug discovery and support the development of natural antifungal agents.

Fresh flowers of *Hibiscus rosa-sinensis* were collected, washed, shade-dried, and powdered. Fifty grams of powdered material were separately extracted using methanol and ethanol through Soxhlet extraction. The extracts were filtered, concentrated, and stored under refrigeration. *Aspergillus niger* was cultured on potato dextrose agar (PDA) medium. Antifungal activity was assessed using the agar well diffusion method with potato dextrose broth. Extract concentrations of 100 mg/mL, 200 mg/mL, and 500 mg/mL were tested, and plates were incubated for 48–72 hours. Zones of inhibition were measured and compared with the standard antifungal drug fluconazole (75 mg/mL).

Both Methanolic and Ethanolic flower extracts of *Hibiscus rosa-sinensis* showed significant antifungal activity against *Aspergillus niger*. The antifungal effect increased with extract concentration, indicating a dose-dependent response. The methanolic extract consistently exhibited higher zones of inhibition than the ethanolic extract at corresponding concentrations. At 500 mg/ml, the ethanolic extract produced a 25 ± 0.31 mm inhibition zone, while the methanolic extract showed 27 ± 0.38 mm, closely comparable to fluconazole (29 ± 0.33 mm). The superior activity of the methanolic extract is attributed to its enhanced ability to extract bioactive phytochemicals such as flavonoids, phenolics and tannins. These results highlight plant flowers as a promising natural antifungal source and establish methanol as a more effective extraction solvent. Such plant-derived bioactive compounds can play an important role in pharmaceutical industries for the development of cost-effective, eco-friendly, and safer antifungal formulations.

Solvent-Responsive, Floral Biomass-Derived fluorescent Carbon Dots from *Catharanthus roseus* for Selective Dead Cell Labelling and Real-Time Gut Imaging in Zebrafish

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The distribution of live and dead microbial populations under therapeutic treatment is a crucial indicator of efficacy. Although multiple techniques exist for microbial viability assessment, fluorescence-based optical imaging remains preferred due to its simplicity and rapid response. However, conventional organic dyes and colorimetric stains are often expensive and cytotoxic, limiting their broader biological and in vivo applications. To address these limitations, we developed a nitrogen-doped, carbon-rich carbon dot-based optical probe (CRCD) through hydrothermal synthesis of *Catharanthus roseus* flower biomass using ethylenediamine as a nitrogen source. The synthesized CRCDs were comprehensively characterized using UV-visible spectroscopy, photoluminescence, XPS, HRTEM, zeta potential, and particle size analysis. The CRCDs exhibited excitation-dependent blue-green fluorescence, pH sensitivity, quasi-spherical morphology, and an average size below 10 nm, with surface functional groups confirmed by FTIR analysis. Systematic evaluation revealed strong environment-responsive fluorescence, with significantly enhanced intensity, photostability, and signal-to-noise ratio in viscous media such as glycerol due to restricted non-radiative relaxation pathways. Importantly, CRCDs selectively labelled dead yeast cells, enabling efficient live-dead microbial discrimination. Furthermore, CRCD labelled yeast facilitated successful in vivo imaging in zebrafish larvae, allowing visualization of nostril uptake and real-time gut motility. These findings establish CRCDs as a sustainable, biocompatible, and dynamic imaging platform for microbial tracking and therapeutic assessment

Neuroprotective Effects of Genistein Against Diethyl Phthalate-Induced Neural Damage in Zebrafish

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Among the multifaceted etiological factors implicated in neurodegeneration, exposure to environmental toxicants represents a significant contributor. Diethyl phthalate (DEP), long regarded as relatively safe, has been increasingly identified in recent studies as a potent inducer of neurodegenerative processes. DEP is a low molecular weight phthalic ester acid that is available in various plastic products, cosmetics, and perfumes, and can be ingested, inhaled, and enter the body through dermal contact. To mitigate the effects of DEP on the brain, genistein was administered. The compound is a naturally occurring isoflavone phytoestrogen, extracted primarily from soybeans, beans, etc. Genistein has been proven to be very effective in reproductive health in dose dependent manner, but its role in neurodegenerative diseases is still not very much explored. So this study will be helpful to understand the effects of DEP and also to understand the role of genistein in mitigating the effects of DEP.

The animal model (*Danio rerio*) was acclimatised for approximately 15 days in the laboratory conditions, maintaining the pH (7-7.5), temperature (25°C-27°C) and photoperiod (12:14 hours, day: night). Animals were given exposure to the chemical for 12 days continuously with the doses of DEP and Genistein, respectively. To analyse its effects on the brain of zebrafish, biochemical analysis and histology were performed.

The exposure of DEP has shown the devastating effects on the brain of zebrafish, increasing the levels of oxidative stress assays and decreasing the levels of antioxidant assays. Histological analysis involving cresyl violet staining reveals the damage caused by the DEP in the structure of the brain. It has also been discovered that the exposure of genistein is helpful in mitigating the effects of DEP in the zebrafish in the dose dependent manner. Immunohistochemistry was also performed to map the pathological features.

Exploration of Drought-and Heat-Tolerant Bacteria from the Hill Regions of Gwalior to Enhance Growth and Stress Resilience in Legume Crops

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Climate change and the increasing incidence of drought and heat stress severely limit legume productivity, particularly in semi-arid regions such as Gwalior. Legumes are vital for food security and soil fertility due to their ability to fix atmospheric nitrogen biologically however, abiotic stresses significantly reduce their growth, yield, and symbiotic efficiency. Plant-associated bacteria can tolerate drought and high temperatures offer a sustainable solution by enhancing plant stress resilience.

This study aimed to isolate, screen, and evaluate drought- and heat-tolerant bacterial strains from hill soils of the Gwalior region and to assess their potential to improve stress tolerance in legumes. Soil samples were collected from hill slopes, and bacterial isolates were screened for tolerance to low water potential (-0.5 MPa PEG) and elevated temperature (50 °C). Plants were inoculated with individual bacterial isolates and compared with uninoculated controls.

The results demonstrated that several isolates significantly enhanced germination rate, root and shoot biomass, chlorophyll content, and relative water content under stress conditions. Notably, isolates AGS-1 and ASG-2 increased shoot biomass and chlorophyll content under combined drought and heat stress compared with the controls. Enhanced stress tolerance was correlated with higher exopolysaccharide (EPS) production and improved plant water status. In conclusion, drought- and heat-tolerant bacterial isolates from local hill soils can effectively promote stress resilience. These bioinoculants show strong potential for sustainable agriculture in stress-prone regions by reducing reliance on chemical inputs while enhancing crop productivity.

Bioefficacy of Ethanolic leaves Extracts of *Catharanthus roseus* Linn. and *Psidium guajava* L. against Human allergen *Aspergillus niger*

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The increasing resistance to synthetic Antifungal agents and environmental concerns have intensified the search for Plant-based alternatives. *Aspergillus niger* is a ubiquitous fungus responsible for food spoilage, agricultural losses and opportunistic infections in humans. Medicinal plants contain diverse bioactive secondary metabolites with antimicrobial properties. *Both the plants* are traditionally used for their therapeutic benefits due to diverse phytoconstituents. This study aims to evaluate and compare the antifungal efficacy of ethanolic leaf extracts of *both plants* against *Aspergillus niger*.

Fresh leaves of *Catharanthus roseus* Linn. and *Psidium guajava* L. were collected, washed, shade-dried and powdered. Fifty grams of powdered material were extracted using ethanol by Soxhlet extraction under controlled conditions. Antifungal activity against *Aspergillus niger* was evaluated using the agar well diffusion method on Potato Dextrose Agar medium. Fungal inoculum was spread uniformly and wells were loaded with extracts at 100 mg/mL, 200 mg/mL and 500 mg/mL concentrations. Fluconazole (75 mg/mL) served as the standard control. Plates were incubated and zones of inhibition were measured to determine Antifungal activity.

Catharanthus roseus Linn. and *Psidium guajava* L. ethanolic leaf extracts exhibited significant antifungal activity against *Aspergillus niger* indicated by clear inhibition zones. The Maximum zone of inhibition was observed at 500 µg/mL, with *Catharanthus roseus* Linn. showing a zone of 19 ± 0.25 mm and *Psidium guajava* L. showing 27 ± 0.46 mm, comparable to standard antifungal drug Fluconazole (29 ± 0.33 mm at 75 µg/mL). *Psidium guajava* L. demonstrated higher Antifungal efficacy likely due to phenolics, flavonoids and tannins that disrupt fungal cell wall integrity and metabolic pathways. The results confirm Ethanol as an efficient solvent for extracting antifungal phytochemicals and highlight these plants as eco-friendly, cost-effective alternatives to synthetic antifungal agents with potential applications in agriculture, food preservation and pharmaceutical development.

Enhanced L-DOPA Production through Tyrosinase from *Bacillus cereus* MUTY-5 under Optimized Environmental and Nutritional Conditions

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Parkinson's disease is a progressive neurological disorder caused by degeneration of dopamine-producing neurons, leading to impaired motor functions. L-3, 4-dihydroxyphenylalanine (L-DOPA), a natural precursor of dopamine, remains the most effective therapeutic agent for managing this condition. Microbial tyrosinase, a multicopper oxidoreductase enzyme, catalyzes the conversion of L-tyrosine to L-DOPA and plays a key role in biotechnological applications. The present study aims to isolate, characterize, and optimize a potent tyrosinase-producing bacterial strain from industrially contaminated soil, with the objective of enhancing L-DOPA biotransformation through microbial processes.

Industrially contaminated soil samples were collected from various industrial sites of Mandsaur and Neemuch districts of Madhya Pradesh. A total of 48 bacterial isolates were screened for tyrosinase production using L-tyrosine-containing media. Potent isolates were further characterized using biochemical tests and molecular identification based on 16S rRNA gene sequencing. The most efficient strain, identified as *Bacillus cereus* MUTY-5, was subjected to optimization studies to evaluate the effects of environmental parameters (pH, temperature, agitation, and incubation time) and nutritional factors (carbon and nitrogen sources) on tyrosinase production.

Out of 48 isolates, seven showed significant tyrosinase activity, with strain MUTY-5 exhibiting the highest tyrosinase production index (3.07 ± 0.18). Molecular analysis confirmed the identity of the strain as *Bacillus cereus*. Optimization studies revealed that neutral pH (7.0), moderate temperature (35 ± 2 °C), agitation at 120 rpm, and 48 hours of incubation were optimal for maximal enzyme production. Among nutritional factors, glucose and fructose supported higher tyrosinase activity, while ammonium sulfate proved to be the most effective nitrogen source. Enhanced enzyme production under optimized conditions highlights the metabolic adaptability of *Bacillus cereus* MUTY-5 isolated from stressed environments. The study underscores the potential of this strain for extracellular tyrosinase production and its promising application in sustainable L-DOPA biotransformation and industrial biotechnology.

Genetic Algorithm based Sustainable Inventory Model with Price Dependent Demand, Time Dependent Holding Cost, and Weibull Deterioration

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A sustainable inventory model is developed for a single deteriorating item with price dependent demand and time dependent holding cost. Deterioration is inevitable in every type of businesses, particularly for electronic and semiconductor products where early-stage deterioration is more severe. Moreover, shortages often result in partial backlogging, as only a fraction of customers are willing to wait during stock-out periods. To realistically capture these behaviors, a two-parameter Weibull deterioration process is incorporated into the model along with partial backlogging.

The proposed model also includes investment in preservation technology to reduce deterioration effects such as controlling the temperature and humidity of warehouse. Due to the highly nonlinear nature of the total cost function, a Genetic Algorithm (GA) is employed as the primary optimization technique to determine the optimal order quantity and decision variables. Numerical experiments are conducted along with sensitivity analysis to validate the effectiveness of the GA-based solution approach.

The results of this study indicate that investment in preservation technology significantly reduces total cost and mitigates early-stage deterioration effects, while partial backlogging plays a crucial role in balancing shortage and holding costs. The GA efficiently identifies near-global optimal solutions for the nonlinear model. Sensitivity and graphical analyses further reveal that higher deterioration rates and shortage costs increase total cost, whereas appropriate preservation investment improves inventory performance and sustainability.

Using Novel Hybrid SF-MEREC-SWARA-COPRAS MCDM Method for Assortment of Most Sustainable LI-Ion Battery Type

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In response to the escalating threat of global warming and rising average annual temperatures, the global community is aggressively pursuing emission reduction strategies, with the electrification of transport sector acting as a primary pillar. Consequently, Lithium-ion batteries have become the cornerstone of energy storage from modern portable electronics to grid systems. As the market for battery-driven automobiles expands and reliance on classical fuels diminishes, understanding the comparative efficiency of battery alternatives through appropriate optimization becomes crucial. Therefore, the primary objective of this study is to propose a novel hybrid MCDM framework to evaluate and rank six distinct rechargeable Lithium-ion battery alternatives: LFP, NMC, NCA, LCO, LMO, and LTO.

To address this multi-criteria decision-making (MCDM) problem, the study employs a specific mathematical methodology. The framework integrates Spherical Fuzzy sets (SFS) with the Method based on the Removal Effects of Criteria (MEREC) and Stepwise Weight Assessment Ratio Analysis (SWARA). These techniques are applied to determine both the objective and subjective weights of the relevant criteria, ensuring a balanced assessment of data. Subsequently, the Complex Proportional Assessment (COPRAS) approach is utilized to process these weights and rank the battery alternatives based on their relative degree.

However, EV manufacturers face a complex Decision-Making challenge in balancing conflicting performance metrics- such as cost, cycle life, nominal voltage, thermal stability, recyclability, supply chain risk, self-discharge rate, specific energy, and power density, across several available battery types. The results of the analysis identify Lithium Titanate Oxide (LTO) as the optimal choice, yielding a final ranking order of $LTO > NCA > NMC > LCO > LFP > LMO$. The comparative discussion and sensitivity analysis has been conducted to confirm the validity of these findings, which demonstrate the robustness and effectiveness of the proposed model. Ultimately, this framework identifies the most suitable battery technologies to support environmental sustainability.

A Generalized Efficient Class of Estimators for Population Mean under PPS Sampling Using Auxiliary Information

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Population units in practical survey settings often differ considerably in their magnitudes, such as firms varying in workforce size or environmental regions differing in area or density. In such heterogeneous populations, equal-probability sampling becomes inefficient, making Probability Proportional to Size (PPS) sampling a more suitable and reliable approach. Motivated by this need for improved estimation under PPS schemes, the present study aims to develop a refined class of estimators for estimating the population mean using auxiliary information.

A new class of estimators is proposed within the PPS sampling framework, incorporating auxiliary variables to enhance precision. The expressions for the bias and mean squared error (MSE) of the suggested estimators are derived under the first-order approximation. The performance of the proposed class is evaluated through an extensive simulation study and empirical analysis using real-world datasets to assess its practical applicability and robustness.

The comparative analysis demonstrates that the proposed estimators outperform the existing ones, showing markedly lower MSE and higher percent relative efficiency (PRE) values. These findings highlight the improved accuracy and reliability of the refined estimator class in heterogeneous populations. Overall, the study underscores the significance of incorporating auxiliary information in PPS sampling to achieve more efficient population mean estimation.

A Novel Similarity Measure Based on Score Function on Pythagore`An Fuzzy Environment and its Applications to Pattern Recognition of Cancer Tumors using Known and Unknown Symptom Patterns

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Pattern recognition based on similarity measures is crucial for identifying unknown patterns by comparing them with known ones. Such techniques are widely applied in medical diagnosis and other critical research domains, enabling effective decision-making under uncertainty, particularly when data are vague or imprecise.

In this work, a novel similarity measure is proposed using a score function within the Pythagorean fuzzy framework. Several mathematical properties of the developed similarity measure are rigorously established. The proposed method is designed to handle uncertainty more flexibly than existing approaches.

The proposed similarity measure is applied to cancer tumor classification problems involving known and unknown patterns. Comparative analysis with existing methods demonstrates improved discrimination capability and reliability. The results highlight the effectiveness of the proposed approach in medical pattern recognition and its potential significance in clinical decision support systems.

Digital Inventory Model with File Deletion Under Cost Constraints

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The inventory concept involves storing items in warehouses and releasing them at the most suitable time to maximise benefit. Businessmen and farmers use this principle to manage seasonal demand and pricing. Similarly, at digital platform built-in memory space in digital devices (such as laptops, desktops, and tablets) can be viewed as digital warehouses where files created or downloaded by users are stored over longer time. These files may be retained indefinitely or may be deleted when no longer useful. The objective of this paper is to develop a digital inventory model using digital file as an item. It focuses on optimising system reformat risk over time by considering regular file creation and deletion in digital storage systems.

The model assumes constant rates of file creation and file deletion by users over time from time when purchased. A simulation study is carried out to analyse the System Reformat Risk (SRR). Four categories of device users are defined based on real data related to laptop memory sizes and device prices. These categories are used to study system behaviour under varying storage capacities and cost structures, allowing a realistic assessment of digital storage performance.

The results show that Category-I users consistently achieve the best performance, with the lowest reformat risk and highest efficiency, indicating that such systems benefit most from deletion-based optimisation. The analysis confirms that proactive deletion of files and folders effectively reduces digital storage burden and system reformat risk (SRR). Implementing deletion strategies across all user categories, especially high-risk groups, can significantly improve system performance, reduce maintenance costs, and extend device lifespan. The cost analysis further reveals that higher-priced digital devices require a longer time to reach at first reformat time (FRT) and operate with comparatively lower risk, highlighting the practical importance of the proposed digital inventory model.

Physics-Guided Recurrent Learning for Parabolic PDEs in Short-Rate Models for Bond and Option Pricing

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The numerical solution of partial differential equations governing interest rate derivatives remains a central problem in computational finance, particularly within short-rate frameworks where stochastic dynamics generate time-dependent parabolic equations. This study aims to develop a novel, accurate and stable learning-based framework for computing bonds and European options under the Hull-White (HW) interest rate model.

The proposed methodology introduces a hybrid physics-guided recurrent learning architecture that integrates Physics-Informed Neural Networks with Gated Recurrent Units to more effectively capture the temporal structure inherent in short-rate dynamics. The HW stochastic differential equation governing interest rate evolution, together with the corresponding parabolic pricing partial differential equations for bonds and European options, are incorporated into the learning process as soft physical constraints. In addition, Bayesian optimization is employed to systematically tune both architectural and training hyperparameters, enhancing convergence stability, numerical efficiency, and overall approximation accuracy.

Numerical experiments demonstrate that the proposed approach consistently reduces PDE residuals and improves pricing accuracy relative to standard PINN formulations across multiple error norms. Statistical significance is validated through paired hypothesis testing and robustness is confirmed via cross-validation, ensuring that the observed performance gains are reliable and not attributable to random sampling or overfitting. A systematic component-wise analysis further demonstrates the individual contributions of the recurrent architecture, physics-based constraints, and Bayesian hyperparameter optimization to the overall performance improvements. The findings highlight the effectiveness of recurrent physics-informed architectures as a flexible alternative to classical grid-based solvers.

Risk-Aware Hybrid Fuzzy-AI Multi-Criteria Decision Framework for Smart Energy Management in Renewable-Powered Cities of Madhya Pradesh

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The renewable-powered smart city concept entails the deployment of decision-making frameworks that can handle uncertainty, manage the trade-offs among the different objectives, and assist in the distributed coordination. A risk-aware hybrid fuzzy-AI multi-criteria decision-making framework for renewable energy integration in smart buildings is the main contribution of this study, which was tested using five representative buildings in Madhya Pradesh, India.

The proposed approach merges deep learning-based forecasting (LSTM and Transformer) with Interval Type-2 Fuzzy Logic to deal with the uncertainties both in time and operation. A hybrid fuzzy-Bayesian C-OPRAS approach is utilized for the weighting of criteria and ranking of buildings, while qualitative risk factors are modeled through Fuzzy-FMEA-Kano analysis. The NSGA-II/III algorithm is applied for multi-objective optimization to find the optimal balance among energy cost, efficiency, and system resilience.

The findings suggest that the fluctuation in renewable energy generation is the main factor that affects the risk sensitivity of decision weights (centroid ≈ 0.706). The C-OPRAS ranking system places Building 4 at the top of the list, marking it as the most resilient with a score of 100%, which is a result of the low volatility in the battery state-of-charge. The optimization framework proposed produces Pareto fronts that are very well distributed and have rapid convergence, and the sensitivity analysis assures the validity of the results even with changes in decision weights. The framework, in general, shows great flexibility, strength, and clarity, which makes it a good decision-support instrument for the large-scale use of renewable energy in smart cities.

Exploring Tri-Trophic Population Under the Toxicant Environment with Two Types of Functional Responses: The Mathematical Implications

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Environmental pollution poses a serious threat to ecological stability by altering species interactions and survival rates across different trophic levels. Mathematical modelling offers a powerful tool to analyse such complex ecological systems. The objective of this study is to investigate the population dynamics of a tri-trophic food chain consisting of crops, grasshoppers, and birds under a polluted environment, with particular emphasis on the role of pollution-induced mortality on ecosystem stability.

nonlinear mathematical model based on ordinary differential equations is formulated to describe the interactions among the three species. Holling type-II and Beddington–DeAngelis functional responses are employed to represent realistic predator–prey interactions. Pollution effects are incorporated through additional mortality terms acting on all trophic levels. Standard analytical techniques are applied to examine boundedness and equilibrium behaviour, and numerical simulations are performed to support the theoretical results.

The proposed model admits four biologically relevant equilibrium points, namely trivial, axial, planar, and interior equilibrium. Stability analysis reveals that pollution intensity significantly influences the persistence and coexistence of species. Numerical simulations confirm the analytical findings and demonstrate stable population dynamics under appropriate parameter values. Bifurcation analysis with respect to pollution-induced death rates of crops and grasshoppers shows transitions from chaotic behaviour to stable equilibria. The results clearly indicate that increasing pollution can destabilize the ecosystem and lead to population extinction, whereas controlled pollution levels promote coexistence. This study highlights the combined impact of ecological interactions and environmental pollution on long-term ecosystem behaviour and provides useful insights for ecological management, conservation planning, and sustainable environmental policies.

A DDVV-type Inequality for Riemannian Maps into Generalized Complex Space Forms

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The DDVV conjecture is a fundamental curvature inequality relating intrinsic and extrinsic invariants of geometric objects. While it has been extensively studied for submanifolds, its extension to more general mappings remains limited. The objective of this work is to establish DDVV-type curvature inequalities for Riemannian maps from Riemannian manifolds into generalized complex space forms. The study aims to generalize known results, analyze equality cases, and contribute to the understanding of curvature behavior in almost Hermitian geometry.

This research work is purely theoretical and is based on methods from differential geometry. The study uses standard concepts such as Riemannian manifolds, almost Hermitian structures, curvature tensors, and Riemannian maps. The results are obtained by applying Gauss and Ricci equations, along with known algebraic inequalities, to derive curvature relations and analyze equality cases. No experimental or computational methods are involved.

In this work, we study curvature inequalities for Riemannian maps from Riemannian manifolds into generalized complex space forms. The main observation is that intrinsic curvature quantities of the domain manifold are closely related to the extrinsic curvature of the map through a DDVV-type inequality. We obtain explicit bounds involving scalar curvature, normal scalar curvature, and the second fundamental form of the map. The equality cases are also discussed, which help in identifying special geometric situations where the map behaves in an optimal way. These results generalize earlier known inequalities for submanifolds and show that similar geometric relations hold for the broader class of Riemannian maps. The findings contribute to a better understanding of curvature behavior in almost Hermitian geometry and may be useful for further studies in geometric analysis and related areas.

Lattice-based Signature Protocol on hardness of SIS: Strengthening Security and Reducing Signing Key Size for Post-Quantum Cryptography

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The scalable quantum computer efficiently breaks existing public key crypto (PKC) systems, including RSA and Elliptic Curve Cryptography (ECC). These schemes rely on the computational hardness of number-theoretic problems such as integer factorization and the discrete logarithm problem, which can be solved in polynomial time on a powerful quantum computer using Shor's algorithm. To address this emerging challenge, schemes based on the hardness of lattice problems, including the Shortest Integer Solution (SIS) problem, have emerged as a promising solution due to their conjectured resilience to quantum attacks. This work focuses on an important PKC primitive, namely, digital signatures based on lattice problems, specifically, those leveraging the Shortest Integer Solution (SIS) problem, which are well-suited for resisting quantum attacks.

We began by critically reviewing existing SIS-based signature schemes, noting their simplicity and efficiency, but also uncovering a key vulnerability that could allow an adversary to forge signatures. We have developed a new signature protocol that not only eliminates possibility of security leak by enforcing tighter constraints on critical matrices but also reduces the size of the signing key and overall communication cost. A central innovation in our approach is the use of a centred binomial distribution when selecting secret elements, ensuring that required norm bounds for hardness are met.

Our formal security analysis demonstrates that the new scheme is resistant to forgery attempts, and comparative performance tests show notable improvements in signing key size and communication requirements without sacrificing efficiency. Therefore, our proposed scheme not only overcomes the signature forgery but also achieves a reduction in the signing key size, making it more practical for real-world applications in post-quantum cryptographic systems. Overall, this enhanced SIS-based digital signature protocol marks a significant step forward in designing secure, practical cryptographic solutions for the post-quantum environment.

Provably Secure Authenticated Key Exchange Based on Isogeny Class Group Actions and Multivariate Quadratic Polynomials

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As the advent of quantum computing threatens the security foundations of classical public-key cryptography, post-quantum authenticated key exchange (AKE) emerges as a critical primitive for ensuring provably secure and authenticated communication in quantum-capable adversarial settings. Although isogeny-based constructions offer compact key representations and strong mathematical foundations, their secure integration with authentication mechanisms remains challenging, particularly in the presence of impersonation, man in the middle, unknown key-share, and key-compromise impersonation attacks. Addressing these challenges is essential for building practically deployable post-quantum communication protocols.

In this work, we propose an authenticated key exchange protocol that combines the commutative action of the CSIDH class-group along with the MAYO multivariate signature scheme. The protocol employs ephemeral isogeny-based Diffie–Hellman key agreement to establish shared secrecy, while long-term MAYO signatures provide explicit identity authentication and transcript binding. A modular design is adopted in which secrecy and authentication are cleanly decoupled, allowing a transparent security analysis. Carefully structured transcript hashing and domain separation ensure resistance against replay attacks and unknown key-share vulnerabilities.

We formally establish the proof of correctness of construction and analyse its security within the ex-tended Canetti–Krawczyk (eCK) model under standard post-quantum hardness assumptions. Furthermore, we present a comprehensive performance evaluation including symbolic asymptotic complexity analysis and communication-cost comparison with existing post-quantum AKE schemes. The results demonstrate that the proposed CSIDH–MAYO AKE achieves strong security guarantees with practical efficiency, making it a viable candidate for real-world post-quantum secure communication.

A Generalized (k, m) Heron Problem: Optimality Conditions and Algorithm

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The classical Heron problem is one of the earliest geometric optimization problems concerned with minimizing distances under spatial constraints. Motivated by its wide applicability and modern developments in convex analysis, this work introduces a generalized (k, m) Heron problem involving multiple feasible and target sets. The objective is to determine optimal points belonging to k feasible and m target non-empty closed convex sets in \mathbb{R}^n such that the total pairwise distance between these sets is minimized. This generalized formulation unifies and extends several classical distance-minimization problems, including the Fermat--Torricelli and generalized location problems, within a single convex optimization framework.

The problem is formulated using distance functions between convex sets, allowing the application of tools from variational and convex analysis. Fundamental theoretical properties are established by employing subdifferential calculus, projection operators, and normal cone theory. In particular, conditions ensuring existence and uniqueness of optimal solutions are derived, along with necessary first-order optimality conditions. Based on these analytical results, a Projected Subgradient Algorithm (PSA) is developed to compute approximate solutions efficiently. The convergence of the proposed algorithm is rigorously proved under standard assumptions on diminishing step-size rules.

Numerical experiments conducted in two and three dimensional Euclidean spaces demonstrate the effectiveness of the proposed algorithm. The results confirm its stability, geometric accuracy, and computational efficiency across different configurations of convex sets. The generalized (k, m) Heron problem and its solution methodology provide a robust analytical and algorithmic framework for multi-set geometric optimization. This study has significant potential applications in location science, facility planning, robotics, and computational geometry.

Generalized Second-Order Iterative Schemes for Fast Computation Matrix Inverses and Application

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Abstract: Generalized inverses are essential concepts in linear algebra and play a crucial role in various scientific and engineering applications. The notion of matrix inversion is extended to non-square and singular matrices through generalized inverses, especially the Moore–Penrose inverse. Generalized inverses are vital for solving least squares problems, dealing with ill-conditioned matrices. We are examining iterative methods to calculate generalized inverses, which are essential for enhancing the accuracy and speed of numerical algorithms.

Proposed iterative process creates a series of matrices that progressively approximate the Moore–Penrose inverse. Let us say A is a matrix in the complex space $C^{m \times n}$ and $X = A^+ \in C^{m \times n}$. To address rank-deficient problems, the proposed methods belong to projected Newton-type methods and incorporates orthogonal projectors that enforce the conditions $R(X) \subseteq R(A^*)$ and $N(X) \supseteq N(A^*)$. Starting solely from the second Penrose equation $XAX = X$, introducing an arbitrary real parameter $\alpha \in R$, the following iterative scheme was designed:

$$\text{NG: } X_{q+1} = X_q A [(1 + \alpha) X_q - \alpha X_q A X_q]$$

This study introduces a new iterative scheme, referred to as NG. The convergence analysis of this scheme is presented, demonstrating that it achieves both linear and second-order convergence. The effectiveness of the method is illustrated through numerical examples. The results of this scheme are compared with those of existing iterative methods, providing tables that present performance metrics such as the number of iterations, CPU time, and error bounds for calculating generalized inverses. Additionally, the iterative scheme NG is applied to develop an iterative scheme for orthogonal projection associated with the generalized inverse and the obtained iterative scheme is applied in tomography, partial differential equation.

Feature Selection and Classification of Individuals Based on Disease Risk for High-dimensional Time-to-event Data

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Accurate classification of lung cancer patients into clinically meaningful stages remains challenging due to pronounced molecular heterogeneity and its complex association with survival outcomes. The expanding high-dimensional gene expression data necessitates statistically rigorous and interpretable methods capable of translating molecular signals into prognostic risk groups. Prior to classification, identifying highly efficient and significant biomarkers is essential. Addressing this need, the present study employs a structured three-step feature selection technique and subsequently develops a survival-based multi-stage risk stratification model for lung adenocarcinoma.

For application, I analyze high-dimensional gene expression data of lung cancer obtained from the TCGA database. A structured three-stage feature selection scheme is employed, combining penalized regression, likelihood-based screening, and Cox proportional hazards modeling to select the most efficient prognostic markers. Patients are subsequently classified into multiple risk levels using survival-adapted classification and regression trees that identify optimal threshold points for each selected gene. Both conventional maximum likelihood and Bayesian Cox models are applied under univariate and multivariable settings to estimate survival effects and quantify uncertainty.

The results demonstrate that the proposed framework effectively identifies the 5 most statistically relevant gene expressions out of 60,432 gene expressions using a three-step feature selection technique that exhibits strong and consistent associations with overall survival. Classification based on multiple marker-specific thresholds reveals clear and monotonic risk gradients, with higher stages corresponding to substantially increased hazard. Bayesian and frequentist estimates show close agreement, confirming the robustness of the findings. This multi-stage risk stratification approach enhances interpretability beyond traditional regression coefficients and enables finer discrimination of patient prognosis. Importantly, the methodology is general and applicable to any time-to-event analysis, highlighting its potential utility in translational oncology and precision medicine.

Delayed Eco-epidemic Dynamics with Allee Effect in Prey Population

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Eco-epidemic models play an important role in understanding the combined effects of ecological interactions and infectious diseases. In many biological systems, the Allee effect significantly influences population survival at low densities, while time delays arising from gestation and infection processes affect long-term dynamics. This study aims to investigate the impact of Allee effect and time delay on the stability and behavior of an eco-epidemic system.

In this work, a nonlinear eco-epidemic model is formulated using a system of delay differential equations incorporating Allee effect in prey growth, a Holling type II functional response for predation, and a gestation delay in the predator population. Positivity and boundedness of solutions are established to ensure biological feasibility. The basic reproduction number is derived to determine disease persistence or extinction. All biologically feasible equilibria are obtained, and their local stability is analyzed for both the non-delayed and delayed systems using linearization and characteristic equations.

The results show that the Allee effect introduces critical population thresholds and multiple equilibrium states, which strongly influence system stability and extinction scenarios. Time delay is found to play a destabilizing role, leading to the emergence of sustained oscillations through Hopf bifurcation, representing recurrent outbreaks and predator-prey cycles. Numerical simulations support the analytical findings and illustrate how variations in the Allee parameter and delay length alter the qualitative dynamics. The combined influence of low-density effects and gestation delay significantly modifies coexistence conditions and resilience of the ecosystem. These findings highlight the necessity of incorporating both Allee effects and biological delays in eco-epidemiological models to better understand real-world population dynamics, disease persistence, and ecosystem management. The proposed framework contributes to theoretical ecology by offering deeper insight into disease-driven population regulation and delayed predator-prey interactions.

Early-stage Characterization of Preformed Fragments Inside Dense Explosion Environments

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Characterizing the initial velocity of fragments during High Explosive (HE) detonation is crucial in explosion physics. Conventional techniques, such as Flash X-ray and Shadowgraphy, are commonly used for tracking high-velocity fragments but lack accuracy during the early explosion phase. This study presents a novel imaging technique using Digital Inline Holography (DIH) with sub- μs effective exposure to visualize preformed fragments in the initial phase of the explosion.

Experiments were conducted using two aluminum-cased detonators, Det-1 and Det-2, with different explosive masses. For controlled fragmentation, 6 mm Stainless Steel (SS 304 Grade) spherical preformed fragments were used in single- and three-fragment configurations. The three-fragment configuration was designed to study the early-stage shock-fragment and fragment-fragment interaction in an explosion.

The developed imaging technique enabled reliable mapping of fragment motion within dense explosion clouds, revealing that Det-2 imparted nearly 20% higher fragment velocities than Det-1 across both fragment configurations in all trials. Also, fragment deceleration was observed due to varying effective density (ρ_{eff}) within the explosion cloud. This exerts a drag force on the fragments, lowering their velocities inside the explosion cloud. In the three-fragment setup, the third fragment recorded the highest velocity, likely due to molecular-level shock-induced energy transfer. Microstructural analysis through SEM revealed transgranular ductile fractures in Det-1 fragments, which absorbed more energy, leading to lower velocities despite the higher explosive content compared to Det-2. This advanced imaging system enhances early-stage velocity measurements in HE detonation.

Comparative Analysis of Lattice Parameter and Cohesive Properties in BCC Transition Metals: Iron, Molybdenum, Tungsten, and Tantalum

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In this work, a detailed computational investigation on the cohesive energies and equilibrium lattice constants of four selected body-centered cubic (BCC) transition metals: iron (Fe), molybdenum (Mo), tungsten (W) and tantalum (Ta). They have great strength and excellent high temperature thermostability, thus making them indispensable materials for the aerospace, nuclear and defence applications. The primary purpose of these investigations is to prove quantitative measurements and comparisons of their basic bonding characteristics, providing important first map data for selecting and designing materials in extreme environments that require structural reliability.

For describing the atom interactions, a molecular dynamic was developed using the Embedded Atom Method (EAM). The total energy was calculated with the aid of parametrized pair potentials and embedding functions. For each metal, the best BCC structure was simulated, and energy of the system was calculated in the scope of lattice parameter. The equilibrium structure was figured out by atomic minimal energy relaxation in Newton-Raphson iterations, and this minimization led to a mechanical equilibrium with small net forces on all atoms. This way it predicts the stable lattice parameter and cohesive energy per atom under bulk-like conditions.

The results show strong patterns in atomic bonding strength. Tungsten shows the highest cohesive energy, followed by molybdenum, tantalum, and iron. This hierarchy corresponds directly towards the established thermal stabilities and melting temperatures of these metals. The estimated equilibrium lattice constants are in great agreement with previously reported experimental values, supporting the EAM potential parameterization. These findings offer critical quantitative insights into the structure-property interactions that control mechanical strength and phase stability in refractory BCC metals. The study provides a reliable computational framework for evaluating alloy compositions and optimizing processing parameters, contributing to the development of next-generation materials for demanding technological applications.

Design And Experimental Validation of an Energy-Efficient Hybrid Battery Cooling System for Hybrid Electric Vehicles

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Lithium-ion battery packs used in hybrid electric vehicles experience severe thermal stress due to high ambient temperatures, repeated charge-discharge cycles, and transient load conditions. Excessive temperature rise and non-uniform thermal distribution accelerate battery degradation, reduce energy efficiency, and increase the risk of thermal runaway. Conventional liquid battery cooling systems are constrained by ambient air temperature and cannot provide effective below-ambient cooling, while continuously operated thermoelectric systems impose high auxiliary energy penalties. The objective of this research is to develop an energy-efficient hybrid battery cooling system capable of maintaining battery temperature within the safe operating range.

A hybrid battery cooling system was designed and fabricated by integrating a liquid-based cooling loop with selectively operated thermoelectric Peltier modules. Ethylene-glycol-based coolant enhanced with CuO nanofluid was circulated through the battery cooling loop to improve convective heat transfer. A solenoid-controlled bypass mechanism enabled time-bound activation of thermoelectric modules only during thermal transients such as rapid charging or high discharge events. The system was experimentally evaluated under controlled inlet temperature conditions, variable coolant flow rates, and operating scenarios representative of hybrid electric vehicle battery heat generation.

The experimental investigation demonstrated that the proposed hybrid battery cooling system provides substantial improvement in thermal performance with significantly reduced energy consumption. Results indicated up to 31.6% enhancement in coolant temperature reduction and approximately 37-40% improvement in overall heat-transfer coefficient compared to conventional liquid battery cooling systems. Selective operation of thermoelectric modules restricted auxiliary power consumption to nearly 130 W, achieving about 35-40% energy savings relative to continuously operated thermoelectric cooling architectures. The system successfully achieved below-ambient coolant temperatures during peak thermal loads, ensuring improved temperature uniformity and enhanced battery thermal safety. The hybrid configuration effectively balances cooling performance and energy efficiency, addressing key limitations of existing battery thermal management systems and offering a scalable solution for hybrid electric vehicle operation under high ambient conditions.

Design, Development and Qualification of Liquid Nitrogen-Based Refrigerated Transportable Container ‘SHIVAY’

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SHIVAY (Sheetal Vahak Yantra) is a Liquid Nitrogen (LN₂) based novel technology, developed in RRCAT, for controlled temperature and humidity transportation of perishables like fruits, vegetables, fisheries etc. It is 100% eco-friendly and can maintain temperature from -40°C to +20°C and humidity levels from 30% to 90% RH. This paper presents comprehensive description of 40' SHIVAY system development, including thermal design, fabrication, testing and qualification of the system.

Thermal design has been carried out to achieve reduction of heat in-leaks through insulated system. Also, temperature uniformity analyses have been performed to optimize air flow patterns and temperatures inside the system. Standard 40' Dry ISO shipping container has been modified and insulated for fabrication of SHIVAY system. Subsystems required for operation including LN₂ Dewars, heat exchanger, fans, sensors, valves, PLC controller, HMI have been developed and incorporated inside the system. Air Leak testing of the system and temperature measurement for uniformity has been carried out as per ISO1496-2.

Based on thermal analyses studies, system has been insulated with optimum insulation configuration to minimize LN₂ consumption. Based on temperature uniformity analyses results, height of bottom recirculation channels has been optimized and air deflector at inlet have been incorporated to ensure proper air distribution. Due to these modifications, temperature uniformity within 1°C inside the system has been achieved. The system has been qualified for leak tightness in accordance with ISO1496-2. The measured leak rate was 186 LPM at a differential pressure of 250 Pa, which is well within the permissible limit of 330 LPM. The system has also been extensively tested for thermal performance validation. Experimental and simulation results show good agreement with difference in overall LN₂ consumption values within 15%. System has also been deployed for field trials involving transportation of perishable goods.

Design and Characterization of Two-Way Shape Memory Alloy (SMA) based Actuator for Aberration Correction Applications

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SMA based actuators utilize temperature-dependent martensite–austenite phase transformation for wavefront aberration correction in space- and ground-based telescopes. Wavefront aberrations caused by thermo-elastic deformation due to temperature variations, gravity-induced deformation, residual mirror stress, and optical misalignment degrade image quality. SMA actuators actively deform the mirror surface to match the aberration profile, thereby restoring optical performance. A serpentine geometry is employed to amplify displacement while maintaining uniform strain distribution and mechanical robustness.

A NiTi serpentine actuator was designed, simulated, fabricated, and experimentally evaluated. Coupled thermo-mechanical finite element simulations incorporating heat transfer and solid mechanics were performed to predict temperature-dependent phase transformation, displacement response, and stress evolution for varying actuator thicknesses and lengths. A cyclic thermo-mechanical training protocol was developed to induce stable TWSME without external biasing elements. DSC was used to determine transformation temperatures, while XRD, EDS, elemental mapping, and SEM were employed for microstructural and compositional characterization. A laser-based optical system using a photosensor is employed for micro-actuation measurement. Temperature dependent tensile testing used for the change of stress and strain in martensite and austenite phases.

DSC confirmed transformation temperatures suitable for Joule heating-based actuation. XRD analysis revealed training-induced martensitic variant reorientation without secondary phase formation, while EDS and elemental mapping verified near-Equi atomic composition (Ni–53.8%, Ti–46.2%). SEM showed surface morphology evolution after training, indicating stabilized internal bias stresses for two-way actuation. Numerical simulations shows that minimum actuator thickness yields the highest displacement with a 27.5% increase, while increased actuator length reduces stress concentration by 6.2%, enhancing mechanical reliability. Temperature-dependent tensile testing showed that the austenite phase exhibits lower strain and stress than the martensite phase. A stable two-way shape memory effect was achieved through thermo-mechanical training, resulting in a repeatable bidirectional actuation stroke of 9.15 μm at 5 A.

Computational Fluid Dynamics Analysis of a Quonset-Shaped Solar Tunnel Dryer for Performance Enhancement

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This research aims to optimize the operational parameters of a solar tunnel dryer (STD) using computational fluid dynamics (CFD) by examining the airflow behaviour and thermal characteristics crucial for effective solar drying. The study focuses on the temperature distribution and airflow in a Quonset-shaped STD operating in mixed-mode.

A three-dimensional CFD model will be created to simulate steady-state fluid flow and heat transfer, with ambient air entering the tunnel at 300 K and 0.5 m/s under solar radiation. Fixed boundary conditions will be used to assess thermal and airflow characteristics within the STD.

The simulation is expected to demonstrate that mixed-mode operation significantly improves both temperature and airflow uniformity within the dryer, resulting in reduced drying times and increased drying capacity. High-temperature zones will be notably located around the absorber surface and along the tunnel's length, while airflow patterns will reveal areas of recirculation and velocity gradients. Findings suggest that enhancing thermal insulation and optimizing the glazing of the transparent cover could further elevate thermal efficiency. At 0.5 m/s the temperature at outlet is about 324 K which is maximum from all mass flow rate of air (0.5-3.5 m/s, in the interval of 0.5 m/s) whereas the average pressure at outlet was around 0.00156 Pa which means accumulation of statical pressure in STD. Also, it is advised that the outlet features smooth, curved joints to minimize pressure loss and promote better airflow uniformity. Overall, the findings underscore that a CFD-based design optimization not only enhances the efficacy of STDs but also contributes significantly to more efficient post-harvest processing of agricultural products.

Synergistic Hepato-Neuroprotective Effects of Natrum Sulphuricum and Natrum Phosphoricum against Alcohol Acetaminophen Induced Liver Cirrhosis and Associated Brain Dysfunction

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The liver is the central metabolic and detoxifying organ, and its chronic injury leads to systemic metabolic failure and neurological complications. Combined exposure to chronic alcohol and acetaminophen (APAP) synergistically accelerates liver cirrhosis through oxidative stress, hypoxia, and impaired energy metabolism, ultimately affecting hepatic and brain function. Natrum sulphuricum (NS) and Natrum phosphoricum (NP), classical biochemic remedies under the AYUSH system, are traditionally used for hepatic and neurological disorders. The present study aimed to evaluate the therapeutic efficacy of NS, NP, and their combination in preventing alcohol-APAP-induced liver cirrhosis and associated brain dysfunction.

Experimental animals were divided into six groups: normal control, alcohol control, liver cirrhosis (alcohol + APAP), and liver cirrhosis treated with NS, NP, or their combination. Cirrhosis was induced using 4.5% alcohol with APAP (300 mg/kg body weight) for seven days, followed by four weeks of therapeutic intervention. Biochemical markers, antioxidant status, glycolytic enzyme activities, and oxidative stress indices were evaluated using standard enzyme assays. Molecular alterations in stress- and hypoxia-related pathways were analyzed through semi-quantitative RT-PCR and Western blotting.

Alcohol-APAP co-exposure caused severe oxidative stress, suppression of antioxidant defenses, disruption of glycolytic metabolism, and activation of hypoxia-associated molecular pathways in liver and brain tissues. Treatment with NS and NP significantly restored antioxidant enzyme activities, normalized metabolic enzymes, and downregulated stress-responsive signaling pathways. Notably, the combined NS+NP treatment demonstrated superior synergistic efficacy. These findings provide experimental validation for AYUSH-based biochemic therapeutics and highlight the potential of NS and NP as adjuvant interventions for oxidative and metabolic damage associated with liver cirrhosis.

S1P Receptor Functional Antagonist Sensitizes Oral Squamous Cancer Cells towards Standard Chemotherapeutic Drugs in a 3-D Silk-alginate Scaffold-based Co-culture Model

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Despite advancements in the diagnostic and treatment modalities, the 5-year survival rate of OSCC patients has not demonstrated considerable improvement due to a high rate of recurrence and chemo-therapy resistance. Therefore, there is a compelling need to search for new molecular drug-targets for oral cancer. Towards this, S1P signaling and the TME especially the CAFs play a pivotal role in oral carcinogenesis and chemo-resistance. Further, owing to the disadvantages associated with two-dimensional screening methods, there has been a shift towards the application of *in vitro* 3-dimensional (3-D) tumor models which can faithfully recapitulate *in vivo* TME. In this work, we demonstrate the potential of silk-alginate-based 3-D bioengineered OSCC co-culture model for S1P-targeted drug-screening for oral cancer therapy.

CAFs were isolated from oral cancer tissues and characterized via qPCR and immunofluorescence. The 3-D bioengineered scaffolds based on silk fibroin from *Bombyx mori* cocoons and sodium alginate were fabricated using freeze-drying process. The 3-D scaffolds were characterized for various physico-chemical properties. Thereafter, cytocompatibility and gene expression analysis was done in the oral cancer cell lines-seeded scaffolds. This was followed by migration assay and gene expression analysis of the 3-D SCC-9 cells co-cultured with conditioned media of CAFs. Further, 5-fluorouracil-resistant SCC-9 cell line was developed and characterized. Finally, several compounds targeting S1P signaling along with 5-FU were screened in the 3-D scaffold-based OSCC co-culture model.

The 3-D bioengineered silk-alginate scaffolds showed porous morphology, swelling behavior, and cytocompatibility with both SCC-9 and SCC-25 cell lines. In addition, the 3-D SCC-9 cells and 5-FU-resistant SCC-9 cell line showed deregulated expression of the S1P metabolizing enzymes as well as an increased expression of ABC transporters, EMT and stemness markers as compared to the parent cell line. The SCC-9 cells co-cultured with conditioned media of isolated primary oral CAFs in the 3-D scaffolds showed more migration as compared to the control. The 3-D OSCC co-culture model showed increased expression of ABC transporters, S1P metabolizing enzymes, EMT and hypoxia markers as compared to the 3-D OSCC model. Exposure of SCC-9 cells, 5-FU-resistant SCC-9 cells, 3-D SCC-9 model, and 3-D SCC-9 co-culture model to FTY720, a S1P receptor antagonist, sensitized the cells towards 5-FU and both the drugs showed an additive effect.

The study demonstrated successful generation of a 3-D bioengineered silk-alginate scaffold-based oral cancer co-culture model which recapitulated the properties of solid tumor and further showed potential of FTY720 for OSCC therapy.

Detection Frequency-guided In-house Development of a Multiplex RT-qPCR Assay for Differential Diagnosis of Infectious Etiologies Associated with Adverse Pregnancy Outcomes

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Infectious agents remain overlooked contributors to adverse pregnancy outcomes (APOs) of unknown etiology. Although molecular diagnostics enable sensitive pathogen detection, single-target testing increases cost and turnaround time, particularly in settings with uncertain frequencies of various infections. Hence, the objective of the study was to develop a multiplex RT-qPCR for the simultaneous detection of the most prevalent pathogens.

In-house developed and validated single-target RT-qPCR assays for eight pathogens associated with APOs were used for testing 160 clinical samples. A multiplex RT-qPCR (mRT-qPCR) assay for the most frequently detected pathogen, along with RNase P as an internal control, was developed in accordance with international guidelines, including Minimum Information for Publication of Quantitative Real-Time PCR Experiments (MIQE) and European Joint Research Centre (JRC) recommendations. Analytical performance was evaluated by parametric sensitivity, limit of detection (LOD), single target–multiplex comparison, fluorescence crosstalk analysis, and LOD asymmetric amplification testing.

Among the eight pathogens screened, *Parvovirus B19*, *Brucella spp.*, and *Enterovirus* detected in the highest frequencies were selected for multiplex assay development. The mRT-qPCR assay met JRC standards and showed performance comparable to the corresponding single-target assays. Analytical sensitivity and LOD for single-target assays were 93.87% at 6 copies/ μ L for *Brucella spp.*, 92.78% at 60 copies/ μ L for *Enterovirus*, and 98.96% at 60 copies/ μ L for *Parvovirus B19*. In multiplex format, the mean Δ Ct between single-target reactions and multiplex reactions across all targets was ≤ 1.0 cycle. Fluorescence crosstalk was in acceptable limit. Under asymmetric target concentration conditions, a maximum Ct shift of ≤ 1 cycle was noted for the lowest-abundance copy in all 3 targets. This study demonstrates a detection frequency-guided multiplex RT-qPCR strategy that enables differential diagnosis of infectious etiologies underlying adverse pregnancy outcomes. The approach provides a scalable framework for rational diagnostic panel design and development in clinical and resource-limited settings.

Exploring the Hidden Canal: A Meta-Analysis on Middle Distal Canal Configuration in Mandibular First Molar (Original article)

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Comprehensive knowledge of the internal root canal morphology is essential for achieving predictable outcomes in endodontic procedures, as missed canals or anatomical variations can compromise treatment success. The middle distal canal (MDC) in mandibular first molars (MFMs) is a rare anatomical variant that may lead to treatment failure if undetected. Despite reports across various populations using advanced imaging, the global prevalence, and anatomical patterns of MDC remain unclear due to methodological differences. Objective: This meta-analysis aimed to estimate the worldwide occurrence of the MDC in MFMs and assess the anatomical variations based on population groups and imaging modalities.

Following Reporting Items for Systematic Reviews and Meta-Analyses 2020 guidelines and registered in International Prospective Register of Systematic Reviews (CRD420250643655), a strategic search of five databases was conducted up to March 22, 2025. Eighteen observational studies using the cone-beam computed tomography (CBCT), micro-computed tomography (micro-CT), or clearing techniques were included. Data had been analyzed utilizing a random-effects model with subgroup analysis by region and modality.

The confluent canal type showed the highest pooled prevalence (7.90%). MDC prevalence was the highest in North Indian (5.70%) and Kashmiri (5.00%) populations. Clearing techniques detected more MDCs (2.35%) compared to CBCT (2.00%) and micro-CT (1.00%).

Although infrequent, MDC is clinically significant. Advanced imaging and meticulous canal exploration are recommended for its detection.

Therapeutic Evaluation of Magneto-Primed Soybean Seeds Extract for DPP-IV Suppression and Oxidative Stress Reduction in Type 2 Diabetes.

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Type 2 diabetes mellitus (T2DM) is a prevalent metabolic disorder characterized by insulin resistance, chronic hyperglycemia, oxidative stress, and low-grade inflammation. Noval approach based Dipeptidyl peptidase-IV (DPP-IV) plays a key role in glucose homeostasis by degrading incretin hormones, and its inhibition is an established strategy to enhance insulin secretion. However, concerns regarding the long-term use of synthetic antidiabetic drugs have increased interest in safer, plant-based therapeutic alternatives.

The present study examined the antidiabetic and antioxidant potential of magneto-primed soybean (*Glycine max*) seeds. Seeds were exposed to a static magnetic field (200 mT for 1 hour), and extracts from germinated seeds were assessed for DPP-IV inhibition and antioxidant activity using DPPH and FRAP assays. T2DM rat model was established using a high-fat diet and streptozotocin (30 mg/kg). Comprehensive biochemical, toxicological, and histopathological analyses were conducted, focusing on DPP-IV inhibitors and incretin hormones. Parameters evaluated included PPAR α , GLP-1, insulin, HbA1c, oxidative stress markers, lipid profile, HOMA-IR, hepatic enzymes, inflammatory cytokines, and pancreatic histology.

Magneto-primed soybean extracts showed significantly higher DPP-IV inhibition, antioxidant activity, and reducing power than untreated soybean. In diabetic animal models, supplementation markedly lowered body weight gain, blood glucose, insulin resistance, and HbA1c. Significant improvements were observed in lipid profile, antioxidant enzymes, liver function markers (SGOT, SGPT, ALP), and renal parameters. The extract achieved $73.3 \pm 2.9\%$ DPP-IV inhibition, activated PPAR α signalling, and suppressed p-eIF2 α expression. It reduced HOMA-IR, lipid peroxidation, and inflammatory cytokines (TNF- α , IL-6), while restoring PI3K/Akt insulin signalling and improving pancreatic histoarchitecture, demonstrating strong therapeutic efficacy against T2DM. Overall, magneto-priming markedly enhances the therapeutic efficacy of soybean seeds, highlighting their potential as a functional food-based strategy for the management of type 2 diabetes and associated metabolic complications.

A Study to Assess the Effectiveness of Planned Teaching Programme on Knowledge Regarding Prevention of Oral Cancer Among Adults in Selected Rural Area at Bhopal [Mp]

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Oral cancer represents a significant and growing public health burden, particularly in developing nations like India, where risk factors such as tobacco use are prevalent. A study conducted among 50 adults in a rural area of Bhopal aimed to assess and improve knowledge on its prevention. Initially, pre-test findings revealed a concerning knowledge gap, with 44% of participants possessing inadequate understanding, 32% moderate, and only 24% adequate awareness. This highlighted a critical need for targeted health education in the community. Subsequently, a structured Planned Teaching Programme (PTP) was implemented, focusing on etiology, risk factors, and early signs of oral cancer.

The post-test results demonstrated a remarkable improvement, with 80% of adults achieving an adequate knowledge score and the remaining 20% scoring moderately; no participant retained inadequate knowledge. This stark contrast between pre- and post-test scores confirms the high effectiveness of the educational intervention. The significant increase in knowledge underscores the power of simple, well-designed teaching programs in empowering rural populations.

The importance of this finding is substantial. Enhanced community knowledge is the cornerstone of primary prevention, encouraging the avoidance of risk factors like tobacco and promoting early detection through self-examination and professional screening. For public health policy, this study validates that low-cost, community-based educational strategies can be a potent tool in the fight against oral cancer. Integrating such planned teaching into routine village health outreach programs could lead to reduced incidence, earlier diagnosis, and lower mortality rates from this largely preventable disease.

**Prevalence of *Ibtida e'Usr al-Tamth* (Primary dysmenorrhea)
and its Relation to Lifestyle and Dietary Habits in
Medical students of AYUSH Campus**

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Primary dysmenorrhea is a common menstrual disorder that causes significant pain and functional impairment in women of reproductive age, especially students. While lifestyle, dietary practices, menstrual patterns, and hematological status have been linked to dysmenorrhoea in various populations, evidence among AYUSH medical students is sparse. This study estimated the prevalence of primary dysmenorrhea and examined its associations with lifestyle behaviors, and dietary habits among female AYUSH students.

A prospective, cross-sectional study was conducted among 350 female AYUSH medical students (18–30 years) using a pretested structured questionnaire to collect data on sociodemographic factors, menstrual history, lifestyle and dietary habits, stress, sleep satisfaction, and anemia indicators. Prevalence was estimated by descriptive statistics, with associations examined using Chi-square, Pearson's, and Spearman's tests. Univariate logistic regression identified factors associated with dysmenorrhea, reporting odds ratios (OR) with 95% confidence intervals; $p < 0.05$ was considered significant.

The prevalence of primary dysmenorrhea was 73.1%. Univariate analysis identified several significant associations: early first experience of menstrual pain ($\chi^2=19.77$, $p < 0.001$), presence of menstrual clots ($\chi^2=10.01$, $p=0.0016$), duration of menses ($\chi^2=7.23$, $p=0.027$), examination/test-related stress ($\chi^2=4.56$, $p=0.0328$), appetite status ($\chi^2=10.59$, $p=0.005$), and meat consumption frequency ($\chi^2=9.97$, $p=0.0188$). Hemoglobin level showed a significant negative correlation with dysmenorrhea severity (Spearman's $r = -0.107$, $p=0.0446$). Univariate logistic regression demonstrated that poor appetite significantly increased the odds of dysmenorrhea (OR=1.94), followed by higher meat consumption (OR=1.39). Other variables, including sleep satisfaction, physical activity, junk food intake, and socioeconomic factors, were not significantly associated. Primary dysmenorrhea is highly prevalent among AYUSH medical students and is associated with specific menstrual characteristics, dietary habits, stress, and hemoglobin status. Integrative lifestyle and nutritional strategies may help mitigate its impact.

Evaluation of the Efficacy and Safety of *Hijāma-bil-Shart* (Wet Cupping) in the Management of Cervical Spondylosis: A Randomized Controlled Clinical Trial

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Cervical spondylosis is a prevalent degenerative disorder of the cervical spine, commonly associated with chronic neck pain, restricted mobility, functional disability, and reduced quality of life. Conventional management options often yield short-term symptomatic relief and may pose limitations with prolonged use. *Hijāma-bil-Shart* (wet cupping), a regimenal therapy described in Unani medicine, has traditionally been used for musculoskeletal disorders; however, its clinical efficacy requires systematic evaluation. This study aimed to assess the efficacy and safety of *Hijāma-bil-Shart* in comparison with Transcutaneous Electrical Nerve Stimulation (TENS) in patients with cervical spondylosis.

An open-label, randomized controlled trial compared *Hijāma-bil-Shart* with TENS in patients with cervical spondylosis. Fifty-three participants were randomized to *Hijāma-bil-Shart* (n = 26) or TENS (n = 27), and 44 completed the six-week intervention (22 per group). Treatments were administered weekly. Outcomes were assessed at baseline and post-treatment using NPQ, NPAD, SF-36, and goniometric cervical range of motion, with safety monitored via routine hematological and biochemical tests.

Post-intervention analysis revealed statistically significant improvements in pain intensity, functional disability, cervical mobility, and quality-of-life scores within both treatment groups ($p < 0.05$). Notably, patients receiving *Hijāma-bil-Shart* demonstrated a markedly greater magnitude of improvement across all outcome measures when compared with the TENS group, indicating superior clinical efficacy. Enhanced cervical range of motion and broader improvements in physical and psychosocial domains of quality of life further underscore the therapeutic relevance of this regimenal intervention. Importantly, the absence of serious adverse events or clinically meaningful laboratory alterations highlights the favorable safety profile of *Hijāma-bil-Shart*. These findings suggest that *Hijāma-bil-Shart* offers a clinically effective, safe, and cost-efficient non-pharmacological alternative for managing cervical spondylosis. Its comparative superiority over TENS supports its inclusion within evidence-based complementary and integrative pain management frameworks, warranting further large-scale and long-term investigations.

Assessing Students' Satisfaction and Learning Outcomes Following a Breastfeeding Skills Workshop

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Breastfeeding is universally recognized as the most natural and beneficial form of infant nutrition. The World Health Organization (WHO) and UNICEF recommend the early initiation of breastfeeding within one hour of birth, exclusive breastfeeding for the first six months of life, and continued breastfeeding along with appropriate complementary foods up to two years of age or beyond. Breast milk provides optimal nutrition, strengthens immunity, supports cognitive development, and forms a critical foundation for lifelong health and well-being.

1. To evaluate students' satisfaction with the content, delivery, and facilitation of the workshop.
2. To measure changes in students' knowledge before and after the workshop.

The research method adopted for the present study was a Quantitative research approach, because the present study aimed to assessing students' satisfaction and learning outcomes following a breastfeeding skills workshop. Selection of institution was done by probability convenient sampling technique. They were selected by probability purposive sampling technique. The Conceptual framework used for the study was Roy's Adaptation Model based on general system theory. Tool used for the study was self prepared breastfeeding practice checklist and likart satisfaction scale. The collected data was tabulated and analyzed by using both descriptive and inferential statistics.

The findings of mean and SD of pre were 12.21, 4.38 & In post test 22.82 & 4.23 respectively. The pre-test scores revealed that majority of college girls i.e. 68 (68%) had poor breastfeeding practice skill. No college girls had adequate knowledge regarding Breast feeding practice .After the administration on Breastfeeding skills workshop the post test scores shows that majority of college girls i.e. 78 (78%) had adequate Breastfeeding skills practice,& no body have poor practice skill. Table 3 evident that majority of the students i.e. 60(60%)have excellent satisfaction, 26 (26%) students have high satisfaction level, only 4(4%) students have poor satisfaction level from the Breastfeeding skill workshop. This indicates that the Breastfeeding Practice skill workshop was very effective in increasing the knowledge of college girls regarding Breastfeeding Practice.

Neurological Soft Signs in Drug-Naïve Patients with Schizophrenia: A Cross-Sectional Study

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Neurological soft signs (NSS) are minor neurological abnormalities frequently reported in schizophrenia and considered indicators of neurodevelopmental dysfunction. Studying NSS in drug-naïve patients eliminates confounding medication effects. Objective of the study was to evaluate the prevalence and pattern of NSS in drug-naïve schizophrenia patients using the Neurological Evaluation Scale (NES), and to identify soft signs absent or less frequently found in this group.

This cross-sectional study was conducted in the Psychiatry Department of a tertiary care hospital. Patients aged 18–60 years meeting ICD10 criteria for schizophrenia and never treated with antipsychotics were included.

Sixty antipsychotic-naïve individuals meeting ICD 10 criteria for schizophrenia were assessed with NES. Statistical analyses examined NSS prevalence and associations with clinical variables.

NSS were present in 85% of patients. Sensory integration and motor coordination deficits were most frequent. Some soft signs such as stereognosis, cerebral dominance abnormalities, and extinction did not show significant elevation in this group. Conclusions: NSS are highly prevalent in drug-naïve schizophrenia, supporting intrinsic neurological abnormalities. Lack of significant stereognosis, cerebral dominance, and extinction abnormalities suggests differential sensitivity of NSS subcomponents in early schizophrenia.

Urease-FITC Based Fluorescent Sensor Coupled with Smartphone Imaging for Point of Care Urinary Urea Monitoring

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Urea is a key biochemical indicator of renal function, and its timely measurement is essential for early detection and management of kidney disorders. This work aims to develop a simple, portable, and cost-effective fluorometric sensor for quantitative urea detection using a paper-based platform integrated with smartphone imaging

The sensor was fabricated by functionalizing paper with urease and fluorescein isothiocyanate (FITC). Urea-induced enzymatic hydrolysis generated ammonia, increasing local pH and enhancing fluorescence. Fluorescence signals were captured under UV illumination using a smartphone and analysed via RGB-based image processing across 10–50 mM urea concentrations.

The developed Paper@urease-FITC fluorometric sensor demonstrated a clear, concentration-dependent enhancement in fluorescence intensity with increasing urea levels, confirming the effective coupling between urease-mediated hydrolysis and pH-sensitive FITC signaling. RGB-based image analysis enabled accurate quantification of fluorescence from smartphone-captured images, showing excellent linearity across the clinically relevant urea range of 10–50 mM. Comparative studies using a smartphone-based UV box, fibre optic fluorescence system, and confocal laser scanning microscopy (CLSM) revealed strong agreement among platforms. Notably, the smartphone-assisted UV box method exhibited a high correlation with CLSM results ($R^2 > 0.98$), validating its analytical reliability despite markedly lower instrumental complexity and cost. Regression analysis, Bland–Altman plots, and Concordance Correlation Coefficients further confirmed minimal bias and strong concordance with reference techniques. While CLSM provided superior spatial resolution, the UV box–smartphone combination emerged as the most practical approach for point-of-care use due to its portability, affordability, and operational simplicity. The paper-based format also ensured rapid response, low reagent consumption, and disposability, making the system well suited for decentralized and resource-limited healthcare settings.

A Dual *In Silico* and *In Vitro* Evaluation of an Antiviral Herbal Drug for Respiratory and Gastrointestinal SARS-CoV-2 Infection: A Preparedness Strategy Against Emerging Variants in the Post-Pandemic Era

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Background and Objective: In the post-pandemic era, new SARS-CoV-2 variant outbreaks persist, with significant gastrointestinal involvement and viral shedding in stool and sewage. This study aimed to evaluate herbal drug using *in silico* and *in vitro* assays for dual antiviral efficacy against emerging SARS-CoV-2 variants in both the lung and gut infections.

Materials and methods: The herbal formulation comprising Bhunimba, Maricha, and Tulasi was evaluated using *in silico* ADMET and molecular docking against SARS-CoV-2 Mpro and hACE2 receptors. Antiviral efficacy was assessed *in vitro* in lung (A549) and gut (Caco-2, HT-29) cell lines using cytotoxicity assays, RT-qPCR-based viral load estimation, and ACE2 expression analysis.

Result: The ADMET indicated that Andrographolide, Piperine, and Eugenol possess physicochemical properties compatible with oral bioavailability, supporting their suitability as therapeutic candidates. Molecular docking showed that the selected phytochemicals exhibit moderate to strong binding affinities toward both SARS-CoV-2 main protease (Mpro) and the human ACE2 receptor, highlighting their potential to interfere with viral replication and host-virus interactions. Among them, Andrographolide demonstrated the strongest binding to Mpro (-6.8 kcal/mol) and favorable interaction with ACE2 (-6.3 kcal/mol), suggesting a prominent dual inhibitory role. Piperine showed stable and comparable binding to both targets (-6.2 kcal/mol), indicating consistent antiviral potential, while Eugenol displayed moderate yet relevant interactions with Mpro and ACE2. These *in silico* findings were corroborated by *in vitro* results, where the herbal formulation significantly improved cell viability and reduced viral burden in lung (A549) and gut (Caco-2 and HT-29) epithelial cell lines.

Conclusion: The study evaluated a herbal drug with a dual-targeting mechanism that effectively suppresses SARS-CoV-2 infection at multiple stages. Importantly, the formulation's ability to act in both respiratory and gastrointestinal models underscores its relevance for controlling systemic infection and potentially limiting community-level viral spread, including via wastewater, while also improving gut health during infection.

Successful Ayurvedic Management of Decubitus Ulcer (Dushta Vrana) Using Jalaukavacharana: A Clinical Case Study

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Pressure ulcers are chronic non-healing wounds caused by prolonged pressure and ischemia in immobilized patients. In *Ayurveda*, they correlate with *Dushta Vrana*, marked by chronicity, pain, and slough. *Jalaukavacharana*, a *Raktamokshana* procedure described in *Shalya Tantra*, is indicated in such wounds. This study evaluates its effectiveness in successful pressure-ulcer management.

A 24-year-old paraplegic male with a chronic left gluteal decubitus ulcer underwent clinical evaluation and aseptic local debridement. *Jalaukavacharana* using 3–4 medicinal leeches was performed on alternate days for 15 days. Supportive care included *Haridra* dressing, nutrition, physiotherapy, water-bed use, and hygiene. Healing was assessed periodically using the Bates–Jensen Wound Assessment Tool.

Following *Jalaukavacharana*, marked clinical improvement was observed in the chronic pressure ulcer. The wound size reduced progressively from $12 \times 10 \times 5$ cm at baseline to a significantly smaller and shallower lesion by Day 30, with evident reduction in depth and surface area. Exudate and slough decreased substantially within the first two weeks, and healthy granulation tissue formation was observed by Day 14. Epithelialization improved steadily, with well-defined wound margins and restoration of normal tissue color. Quantitative assessment using the Bates–Jensen Wound Assessment Tool showed a reduction in total score from 36 on Day 0 to 27 on Day 7, 18 on Day 14, and 15 by Day 21, indicating significant wound healing. Pain and foul odor were notably reduced within the first week, reflecting improved local circulation and infection control. From an Ayurvedic standpoint, *Jalaukavacharana* aids in alleviating *Rakta Dushti*, reducing local inflammation, and facilitating *Vrana Ropana*. The bioactive constituents of leech saliva, including anticoagulant, vasodilatory, and anti-inflammatory substances, enhance microcirculation, promote neovascularization, and support tissue regeneration. This case highlights the importance of integrating classical *Ayurvedic Vrana Chikitsa* with modern wound care for effective, safe, and cost-effective management of chronic pressure ulcers.

The G-Quadruplex Regulatory Landscape in *Acinetobacter baumannii*: From therapeutic target to the Molecular Control of the RNA-Protein Axis

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Acinetobacter baumannii is a prominent multidrug-resistant pathogen responsible for severe nosocomial infections with limited therapeutic options. This study aims to integrate genome-wide bioinformatic mapping with mechanistic characterization to establish non-canonical G-quadruplexes (G4s) as a novel regulatory layer and potential therapeutic target within the *A. baumannii* genome.

We utilized in silico prediction to identify conserved G4 motifs in essential survival genes. Experimental validation was conducted through biophysical analyses, including NMR and CD spectroscopy, to confirm stable G4 formation in DNA and RNA contexts. We further characterized the G4 motifs using ligand-binding assays with BRACO-19, NMM, and cPDS. Our findings revealed that hfq G4s interact preferentially with full-length Hfq protein via its glycine-rich C-terminal domain, demonstrating a unique autoregulatory mechanism. Ligand-mediated targeting successfully inhibited bacterial growth, disrupted biofilm formation, and downregulated essential genes. These results establish G4s as a promising non-canonical drug target for combating multidrug-resistant *A. baumannii*.

Identification of Epidemiological Risk Factors for Diabetic Retinopathy in Type 2 Diabetes Mellitus Using Secondary Data: A Multivariate Statistical Analysis

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Background and Objective: Diabetic retinopathy (DR) is a leading cause of preventable visual impairment among adults with Type 2 Diabetes Mellitus (T2DM), and its burden is rising in parallel with the global diabetes epidemic. Despite growing recognition, large-scale evidence on epidemiological risk factors in diverse populations remains limited. This study aimed to estimate the prevalence of DR and identify its key demographic, clinical, and metabolic risk factors using large-scale secondary data and multivariate statistical analysis.

Methods: A secondary analysis was conducted on 11,500 adults with T2DM. Demographic, clinical, and biochemical variables were evaluated. DR prevalence was calculated, and group comparisons were performed using descriptive statistics. Pearson correlation analysis assessed relationships between DR and continuous variables, while multivariate logistic regression identified independent predictors. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were reported.

Results and Discussion: The prevalence of DR was 18.0%, with 4.2% presenting sight-threatening DR. Individuals with DR were significantly older and had longer diabetes duration, higher HbA1c levels, and higher prevalence of hypertension and insulin use. DR showed moderate positive correlations with diabetes duration ($r=0.42$), HbA1c ($r=0.36$), systolic blood pressure ($r=0.29$), and age ($r=0.25$). Logistic regression revealed that diabetes duration ≥ 10 years (OR 3.21), HbA1c $\geq 8\%$ (OR 2.47), hypertension (OR 1.89), and insulin therapy (OR 2.14) were the strongest independent predictors. Age ≥ 60 years and male sex were modest predictors, while BMI was not significantly associated. Nearly one in five adults with T2DM had DR, underscoring a considerable disease burden. Longer diabetes duration, poor glycemic control, and hypertension were the most influential risk factors. These findings highlight the urgent need for systematic retinal screening, strict metabolic control, and risk-based stratification to prevent progression to sight-threatening disease. The study provides robust epidemiological evidence to guide clinical decision-making and public health strategies aimed at reducing diabetes-related visual impairment.

In Silico Molecular Docking Reveals the Therapeutic Potential of Green Synthesized Nanoparticles Against Begomovirus - Betasatellite Complex Infecting *Capsicum annuum* in Madhya Pradesh, India

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Capsicum is an economically important horticultural crop valued for its nutritional, culinary, and medicinal importance however, its productivity is increasingly threatened by leaf curl disease caused by begomoviruses and its associated complex transmitted by the whitefly. The present study aimed to investigate the molecular diversity of these viruses infecting *capsicum* in Madhya Pradesh, India, and to evaluate the therapeutic potential of green-synthesized nanoparticles using in silico molecular docking approaches.

Field surveys conducted in major *capsicum* growing regions of Madhya Pradesh revealed typical leaf curl symptoms, including leaf curling, vein thickening, and plant stunting. Viral genomes were detected by PCR and RCA followed by sequencing and phylogenetic analysis. To develop sustainable disease management strategies, green-synthesized silver nanoparticles (AgNPs) prepared using *Rivina humilis* plant extract were evaluated to analyse their interactions with key viral proteins involved in replication and encapsidation.

Sequence analysis confirmed the presence of begomovirus strain with its associated betasatellite of DNA-A (PQ876122, PQ876123, PQ876124, PV033371, PV033372, PQ723750, PV033374) and DNA- β (PV014862, PV014863, PQ963790, PV033373) showing strong relatedness to isolates reported from Bangladesh, India, and Pakistan. Begomovirus infection is mediated by essential viral proteins, including Rep (AC1), which drives viral DNA replication, and the coat protein (CP; AV1), responsible for encapsidation and vector-mediated transmission, with pathogenicity further enhanced by AC2, AC4, and the betasatellite-encoded β C1 protein. In silico docking revealed strong binding affinity of AgNPs with functionally important residues of viral Rep and coat proteins, suggesting disruption of viral replication, assembly, and systemic movement. This study provides first molecular evidence of begomovirus betasatellite complexes infecting chilli in Madhya Pradesh, highlights their genetic diversity, and demonstrates the potential of green-synthesized silver nanoparticles, supported by in-silico analysis, as an eco-friendly strategy for managing chilli leaf curl disease.

Keywords: *Capsicum*, Molecular diversity, *Begomovirus*, *Betasatellite*, Green-synthesized silver nanoparticles, *Rivina humilis*, Molecular docking

An Indigenous Sandwich ELISA for Abrin Detection in Food and Environmental Matrices: A Biodefence-Oriented Study

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Abrin is a highly potent phytotoxin isolated from *Abrus precatorius* seeds and is approximately 75-fold more toxic than ricin, a classified biowarfare agent. Non-availability of antidote necessitates development of rapid and reliable diagnostic tools for timely clinical management. The present study aimed to develop a sensitive, specific, and indigenous sandwich ELISA for abrin detection.

Anti-abrin monoclonal/polyclonal antibodies were generated from hybridoma cell supernatants and rat-antisera, purified, and characterized by indirect ELISA. A biotin-based sandwich ELISA was developed, specificity checked, and validated using in-house blind exercise. Performance of assay was evaluated in spiked food (dairy, beverages, sattu) and environmental matrices (envelopes, leaves, plastic, metal) at 300, 30, and 3 ng/ml.

The developed ELISA demonstrated a limit of detection of 3 ng/ml with a linear dynamic range of 7.8–500 ng/ml. The assay showed high precision, with inter- and intra-assay coefficients of variation ranging from 2.50–6.93% and 4.16–8.11%, respectively. Blind sample exercise further validated the assay performance. High analytical specificity was confirmed with no cross-reactivity against other related toxins. Abrin was successfully detected across matrices, with recoveries ranging from 15.48% to 98.31%. Matrix effect analysis revealed minimal interference in green tea and sattu, while dairy products and acidic beverages exhibited pronounced inhibitory effects. Among environmental matrices, envelopes and leaf surfaces showed superior abrin recovery compared to plastic and metal surfaces. Overall, this study provides a robust diagnostic platform for early abrin detection, supporting informed risk assessment, contamination management, food safety monitoring, and biodefence preparedness. The indigenous development of assay aligns with “Ayushman Bharat” by strengthening early diagnosis and public health response capabilities, and supports “Atmanirbhar Bharat” by enhancing self-reliance in critical biodefence and public health diagnostic technologies.

B-box Domain Protein Integrates Light and Hormone Signaling Pathways to Optimize Seed-to-seedling Transition in *Arabidopsis thaliana*

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The remarkable transformation of a dormant seed to an autotrophic seedling has profound implications for agriculture. Elucidating the molecular processes driving these initial growth phases can enhance knowledge about plant environmental adaptation and promote crop resilience (Armarego-Marriott et al., 2020). We identified a factor from B-box domain containing family, *BBX15* as a crucial regulator orchestrating the transcriptional reprogramming modulating de-etiolation and photosynthetic maturation. We found that during seed to seedling transition *BBX15* genetically and physically interacts with light regulating factor as well as factors involved in auxin, brassinosteroid and ethylene signaling pathways. Histochemical studies indicated tissue-specific induction of *BBX15* by light and phytohormones during de-etiolation. *BBX15* represses cotyledon opening-related genes, including *SAURs*, during de-etiolation. *bbx15* accumulated higher levels of protochlorophyllide; nevertheless, they greened faster than wild type due to more rapid conversion of protochlorophyllide to chlorophyll. Total chlorophyll measurements during the dark-to-light transition indicated that *BBX15* has a role in regulating overall chlorophyll biosynthesis. *BBX15* suppresses *GLK1* and *GLK2* expression during dark-to-light transitions. However, the *glk1/2/bbx15* triple mutant displayed pale cotyledons, indicating that *GLK1/2* are epistatic to *BBX15*. Additionally, *BBX15* expression was reduced in the *glk1/2* mutant indicating a negative feedback loop between *BBX15* and *GLK1/2* that fine-tunes seedling greening under dynamic environmental conditions. Since, *BBX15* functions across multiple developmental phases, it offers a unique opportunity to investigate how this factor spatially and temporally integrates external and internal cues in specific tissues and developmental stages.

Residue-specific Chemical Technology for *in Vitro* and *In vivo* N-terminus Glycine Modification

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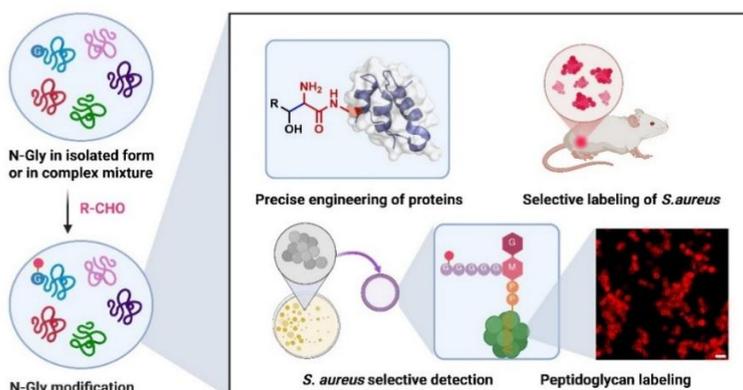
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Precise targeting of biomolecules offers important opportunities in biology and medicine. Here, a chemical technology targets N-terminal glycine (N-Gly) residue, a low-frequency molecular signature involved in regulating protein function and with potential diagnostic and therapeutic relevance. *Staphylococcus aureus* (*S. aureus*), a high-priority human pathogen, has a unique pentaglycine (Gly₅) in the cell wall, which is essential for structural integrity. The increasing prevalence of biofilm-associated infections and multidrug-resistant strains, including methicillin- and vancomycin-resistant *S. aureus*, emphasizes the need to develop strategies that target molecular signatures essential for bacterial growth and biofilm formation.

Here, we employed para-substituted benzaldehydes bearing varied electron-donating and withdrawing groups and performed the reaction with N-Gly peptides/proteins, as well as *S. aureus*. We further functionalized the probe for late-stage diversification to install fluorophores and biotin for imaging and enrichment-based analyses, respectively. The labeling strategy was evaluated in both Gram-positive and Gram-negative bacteria, as well as in co-culture with mammalian cells. *In vivo* labeling of *S. aureus* was assessed in *Drosophila melanogaster* and mouse via blood, skin, and intramuscular infection models.¹

Here, we introduce the first chemical strategy for selectively labeling the N-terminal end of surface-exposed pentaglycine in *S. aureus* using our Rapi-Gly tag technology. Modification of the pentaglycine inhibits biofilm formation and facilitates the breakdown of established biofilms. This method represents a promising tool for the targeted detection and potential therapeutic intervention against *S. aureus* infections.



Tunable effect of divalent cations on tendrill patterning during swarming motility of *Pseudomonas aeruginosa*

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Pseudomonas aeruginosa remarkable adaptability makes it valuable for bioremediation but problematic in healthcare settings, highlighting the need for context-dependent regulation of its colonization. Current research on bacterial swarming is limited by the lack of a minimal media that allows systematic study of factors affecting tendrill patterning. Using a simplified swarming media (SM), we demonstrate that divalent cations tune *P. aeruginosa*'s colonization by modulating cell density, surface charges, and rhamnolipid production without altering flagellar numbers. At colony edges, divalent cations stimulate cell growth and trigger quorum signalling while reducing surface charges. This creates a dynamic environment where bacterial cells with reduced surface charges and active flagella are suspended in an aqueous-rhamnolipid solution experience the Marangoni effect. This leads to non-uniform cell distribution within the colony, concentrating cells at tendrill tips where fresh divalent cations are available. This localized concentration amplifies cell density and rhamnolipid expression through a positive feedback loop, promoting the formation of additional tendrills rather than increasing tendrill thickness. Overall, our findings reveal how a single environmental parameter divalent cation concentration alone can effectively tune bacterial colonization behaviour. This mechanistic insight could enable the development of targeted strategies offering potential applications in both bioremediation and medical contexts, though further research is needed to validate these applications under field conditions.

Nanovesicle-Mediated Delivery of Engineered L-Asparaginase Variant With Enhanced Stability and Anti-Leukemic Effect for Acute Lymphoblastic Leukemia Treatment

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Escherichia coli-derived L-asparaginase (EcA), a crucial component of the acute lymphoblastic leukemia (ALL) treatment regimen, has several limitations that reduce its therapeutic efficacy. The major disadvantages include immunogenicity, serum instability, shorter half-life, and associated glutaminase co-activity, which cause neurotoxicity. To overcome these drawbacks, we employed a dual-strategy that combined rational protein-engineering with an advanced polymeric nanocarrier approach.

Employing protein engineering, a novel EcA variant, KHYW-17-EcA, was developed. After preliminary screening and *in vitro* characterization, immunogenicity, pharmacokinetics, safety, and efficacy of KHYW-17-EcA were tested *in vivo*. To further improve its pharmacokinetics and physiological stability, we encapsulated the enzyme in a polymeric nanocarrier, followed by *in vitro* characterization.

To address the limitations of EcA in ALL therapy, we engineered a novel EcA variant, KHYW-17-EcA, and encapsulated it in a polymeric nanocarrier with the aim to enhance the pharmacokinetic as well as physiological properties. Our comprehensive physicochemical characterization revealed that these nanovesicles (<100 nm) effectively shielded KHYW-17-EcA, along with the wild-type EcA, from proteolytic degradation, increased their *in vitro* half-life and thermal stability, and significantly reduced antibody recognition compared to the free enzymes. Importantly, encapsulated nanovesicles (hereafter, KHYW-17-EcA-NV and WT-EcA-NV) retained catalytic activity and exhibited potent cytotoxicity against human leukemia cell lines (Jurkat, MOLT-4, K562), while sparing non-cancerous human bronchial epithelial cells (HBEC-5i). KHYW-17-EcA-NV demonstrated enhanced stability and anti-leukemic efficacy for a prolonged period of time, 72 hours. With these enhanced properties, these polymeric nanovesicles offer an alternative delivery approach for EcA as well as PEG-conjugated EcA that can potentially overcome its prior limitations and facilitate more efficient clinical application. Taken altogether, this study provides a clinically translatable strategy to overcome long-standing barriers in enzyme therapeutics for the treatment of both primary and relapse childhood ALL.

Refolding Dynamics and Immunoinformatic Insights into *Vibrio cholerae* OmpV for Vaccine Applications

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OmpV is crucial for the pathogenesis of *Vibrio cholerae*, functioning within the bacterium's outer membrane; it presents significant potential as a candidate for vaccine development. Due to its intrinsic β -sheet richness, OmpV tends to form inclusion bodies whenever overexpression is attempted. To achieve a native-like structure, detergents can be utilized during the refolding of OmpV from inclusion bodies. The impact of different detergents is examined on the renaturation of OmpV, specifically non-ionic and zwitterionic detergents. The findings provide valuable insights into detergent selection, with DDM emerging as the best protein refolding agent, facilitating successful structural and functional studies of OmpV. Furthermore, using immunoinformatics, it is established that OmpV carries B- and T-cell epitopes in its exposed extracellular regions. The presence of immunodominant regions makes it easier to employ this protein as a vaccine candidate, as it is stable, non-allergenic, and likely to stimulate successful innate and active immune responses. Overall, with OmpV harboring numerous immunogenic epitopes, it can be employed in subunit vaccines against *Vibrio* spp. and contribute to the development of diagnostic tools for effective disease mitigation.

Phytochemical-Mediated Synthesis of NiO Nanoparticles via *Cinnamomum zeylanicum* Blume Bark: Evaluation of Their Antioxidant, Antidiabetic, Antimicrobial and Photocatalytic Activities

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Green nanotechnology has emerged as a sustainable and cost-effective alternative to traditional chemical synthesis. This study explores the biogenic synthesis of nickel oxide nanoparticles (NiO-NPs) using an ethanol extract of *Cinnamomum zeylanicum* (Dalchini) bark, which serves as a natural reducing and stabilizing agent, and assesses its antioxidant, antimicrobial, and antidiabetic efficacy.

Structural and compositional properties were analyzed using UV-Vis., FTIR, XRD, FESEM-EDX, HRTEM, DLS, Zeta potential, and Raman spectroscopy. The therapeutic potential of both the *C. zeylanicum* extract and the synthesized NiO-NPs were measured by two in vitro antioxidant methods such as DPPH free radical scavenging assay and ferric reducing antioxidant power (FRAP) assay. The antidiabetic activity was assessed by α -glucosidase inhibition assay and the antibacterial activity of NiO-NPs was measured by agar well diffusion.

Characterization revealed a distinct absorption peak at 330 nm in UV-visible spectroscopy, spherical morphology under FESEM, and the presence of NiO-NPs in EDX analysis. The XRD pattern reveals the crystallinity of NiO-NPs with a cubic structure and an average crystal size 21.76 nm. FTIR analysis of both confirms the functional groups of active components present in the extract responsible for the synthesis of NiO-NPs. DLS showed nanoparticle agglomeration and the zeta potential was observed at -22.81 mV. HRTEM revealed nanoparticle dimensions of approximately 10-30 nm. In addition, NiO-NPs demonstrated strong DPPH inhibitory activity and FRAP assay with an IC_{50} value of 53.49 ± 0.06 μ g/mL and EC_{50} value 0.51(mg/mL), respectively and also showed high antimicrobial activity. Moreover, at the 20 μ g/mL concentration, NiO-NPs showed outstanding potential against α -glucosidase enzyme with IC_{50} value of 20.63 ± 0.23 μ g/mL, confirming their antidiabetic activities. NiO-NPs were also used as photocatalytic agents, resulting 74.06 %, degradation of methylene blue (MB) dye in 160 min. Thus, it can be concluded that plant-based synthesis of NiO-NPs may be used in biomedicine as a replacement agent for biological applications.

Development and Evaluation of Colorimetric Loop-Mediated Isothermal Amplification (LAMP) assay for Rapid and Sensitive Detection of Mpox Virus Defense Research and Development Establishment, Gwalior (MP)

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The emergence of COVID-19 pandemic in recent years has highlighted the need of the hour for development of rapid, sensitive and easy to use diagnostic tools. Mpox, a re-emerging viral disease in non-endemic countries is caused by Mpox virus (MPXV), an orthopoxvirus genus member which spreads via animal-to-human or human-to-human transmission. Due to its rapid spread across the globe, WHO has declared it as PHEIC (Public Health Emergency of International Concern) twice, in 2022 and 2024, the years that have witnessed major outbreaks of Mpox. Early detection of MPXV thus plays a crucial role in containment of the outbreak.

To timely control the disease outbreaks caused by Mpox and other emerging viruses, PCR has been a gold standard technique for detection, but since it requires sophisticated instruments, adequate time and well-trained personnel, development of fast, economic, sensitive and effective method such as isothermal assay like LAMP is the need of hour. Herein, we have developed a fast colorimetric detection assay of Mpox using pH sensitive colour changing phenol red dye. The color change is observed due to a drop in reaction pH from alkaline to acidic due to the generation of H⁺ ions resulting from amplification of the target gene. The reported LAMP assay using readily available instrument such as water bath, was successfully demonstrated for the detection of Mpox virus with high sensitivity, reproducibility and selectivity within 35 min.

Due to the simplicity and extensibility of this test, it is applicable in a broad variety of domains, potentially point-of-care diagnostics and lab-on chip studies. The flexible nature of our platform makes it an ideal tool for diagnosis and timely detection of emerging pathogens in future public health emergencies.

Profilin SUMOylation Regulates Stress Granule Aggregate Formation, a Characteristic of Amyotrophic Lateral Sclerosis (ALS) Type Neuro-degenerative Disease

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Neurodegenerative diseases are associated with dysregulation of cytoskeletal and actin-associated proteins, leading to impaired cellular homeostasis and toxic protein aggregation. Post-translational modifications such as SUMOylation play critical roles in regulating the localization, stability, and aggregation of disease-linked proteins including α -synuclein, Tau, and huntingtin. Disruption of these cytoskeletal proteins contributes to the pathogenesis of neurodegenerative disease like amyotrophic lateral sclerosis (ALS). Profilin is an actin-binding protein essential for cytoskeletal organization. Profilin is mutated in ALS, and its mutations cause aberrant aggregation. But the role of SUMOylation in regulating profilin function and toxic aggregation in ALS remains unclear.

SUMOylation of profilin was investigated using a combination of biochemical, proteomic, and cell-based approaches. Affinity purification followed by mass spectrometry was done to identify SUMOylation site on profilin. Site directed mutagenesis and SUMO pathway inhibition were used to assess the functional importance of SUMOylation. Confocal microscopy was performed to examine protein localization, and stress granule accumulation under oxidative stress conditions. Structural changes were analyzed by circular dichroism.

Mass spectrometry analysis identified multiple lysine(s) 38, 54, 108, 116 as the predominant SUMO1 modification site on profilin. Site directed mutagenesis confirms lysine 54 as the primary site for modification. Inhibition of SUMOylation resulted in reduced nuclear localization and increased accumulation of profilin at the nuclear periphery. SUMO deficient profilin exhibited enhanced aggregation and stress granule association under oxidative stress. SUMO-deficient profilin exhibits cellular phenotypes like those observed in ALS-associated profilin mutants. This suggests that profilin is regulated by SUMOylation in neurodegenerative disease ALS. The ALS mutant of profilin C71G showed reduced SUMOylation and pronounced aggregation, which was significantly reduced by SUMO1 overexpression. These results demonstrate that SUMOylation of profilin is important for its localization and solubility, and defective SUMOylation contributes to aggregation driven pathology in ALS.

Title- Multitarget Phytochemical Inhibitors against Colorectal Cancer: An Integrated In Silico Investigation

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Colorectal cancer (CRC) remains a major global health burden due to high morbidity and mortality. Conventional chemotherapy and radiotherapy are limited by systemic toxicity, poor selectivity, and drug resistance. Phytochemicals, known for low toxicity and multitarget potential, offer an alternative therapeutic strategy. This study aimed to identify herbal compounds capable of modulating multiple CRC-associated molecular pathways using an integrated computational approach.

Key CRC-related proteins involved in apoptosis (BCL-2), immune regulation (CD40, CD86, IL-1 β , IL-2, TNF- α), proliferation (Ki-67), and epithelial barrier integrity (ZO-1, ZO-2) were selected as targets. Five phytochemicals—baicalin, berberine, luteolin, quercetin, and glycyrrhizin—were screened using molecular docking. Eight high-affinity complexes were subjected to 200*2 ns all-atom molecular dynamics simulations to assess structural stability. Binding free energies were calculated using MM/PBSA, and interaction energetics were explored through residue-wise decomposition and free energy surface analyses.

Docking revealed stable hydrogen bonding, π - π stacking, and π -cation interactions. MD simulations demonstrated converged RMSD, stable radius of gyration, and preserved solvent accessibility, indicating robust complex stability. MM/PBSA identified BCL-2–baicalin, IL-1 β –baicalin, IL-1 β –licorice, and TNF- α –licorice as the most favorable complexes, dominated by van der Waals contributions. Ligand conformations varied across targets, particularly for licorice, highlighting adaptive binding behavior. Energetically important residues were identified as interaction hotspots. Overall, baicalin and licorice emerged as promising multitarget CRC inhibitor scaffolds, providing mechanistic and energetic insights that support future rational drug design and experimental validation.

Optimisation of Inoculum and Moistening Media for Enhanced Cgtase Production in Solid Substrate Fermentation

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The high production cost of cyclodextrin glucanotransferase (CGTase) remains a major limitation for the large-scale industrial application of β -cyclodextrin (β -CD). Therefore, the development of cost-effective CGTase production strategies is essential for the commercial β -CD manufacturing. In this study, CGTase production was optimised using solid state fermentation (SSF), which is an attractive alternative to conventional submerged fermentation (SmF) methods due to its lower operational costs, higher product concentration, and utilisation of inexpensive agro-industrial residues.

CGTase was produced under SSF using wheat bran as the substrate and *Bacillus* sp. NCIM 5799, a strain known to exclusively synthesise β -CD. The effects of different inoculum compositions, including variations in pH, carbon sources, and nitrogen sources, on CGTase activity were evaluated. As moisture plays a crucial role in SSF, various moistening media were also assessed. Furthermore, statistical optimisation of the selected moistening medium was carried out using Plackett–Burman design (PBD) and Central Composite Design (CCD) to identify the factors significantly influencing enzyme activity.

Optimisation of SSF parameters significantly enhanced CGTase production. An inoculum at pH 10, soluble starch as the carbon source, and peptone as the nitrogen source supported the highest enzyme activity. Various moistening media were also assessed, and Murashige and Skoog (MS) micronutrients only solution supported enhanced CGTase production, likely providing essential moisture and metal ions for increased enzyme activity. Further statistical optimisation revealed $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ as a significant linear factor, with $\text{MnSO}_4 \cdot 4\text{H}_2\text{O}$ – $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ as the most influential factor interaction. Under optimised conditions, using 100% (v/w) inoculum and 100% (v/w) optimised moistening medium, CGTase activity reached 13,653.6 U/gds. The findings demonstrate the potential of SSF as an industrially viable and scalable approach for β -CD production.

Development and Application of a Sensitive Sandwich ELISA for Botulinum Neurotoxin Type E Detection in Food Matrices.

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Botulinum neurotoxin type E (BoNT/E) is a highly potent foodborne toxin frequently associated with outbreaks linked to improperly processed or minimally preserved foods. Sensitive and reliable analytical methods for detecting BoNT/E in food matrices are therefore essential for food safety. This study aimed to develop and validate a sandwich ELISA for BoNT/E detection and to evaluate its applicability across representative food matrices.

A sandwich ELISA was developed using rabbit polyclonal anti-BoNT/E IgG as the capture antibody and mouse polyclonal anti-BoNT/E IgG as the detection antibody. Assay conditions were systematically optimized and analytical performance was evaluated in assay buffer, then applied to spiked meat-based, vegetable-based, and dairy-based food matrices. Sensitivity, linearity, recovery, and precision were comprehensively assessed across all samples.

The ELISA achieved a limit of detection of 1.67 ng/mL in assay buffer with excellent linearity across a broad working range. In food matrices, the assay maintained reliable detection with limits of detection ranging from 6.97 to 15.01 ng/mL in meat-based samples, 5.52 to 12.28 ng/mL in vegetable-based samples, and 20.57 ng/mL in dairy samples. Spike-and-recovery experiments demonstrated satisfactory accuracy with mean recoveries between 86.10% and 124.37%, while precision analysis revealed strong repeatability with mean coefficients of variation below 8% across all matrices. Despite minor matrix-dependent sensitivity reductions, the assay consistently delivered accurate and reproducible results. The developed sandwich ELISA offers high sensitivity, reliable accuracy, and robust precision, making it suitable for BoNT/E detection in complex food matrices and supporting food safety efforts.

Metabolomic Profiling and Mechanistic Evaluation of Eugenol-Loaded Chitosan Nanoparticles Targeting NF- κ B, MAPK, and HDAC in Allergic Airway Inflammation: *In Vivo* and *In Silico* Analysis

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Eugenol, a major phytoconstituent of *Syzygium aromaticum L.*, exhibits strong anti-inflammatory activity and plays a significant role in reducing asthma-linked airway inflammation. To improve its thermal stability and therapeutic potential, eugenol was encapsulated in chitosan nanoparticles prepared via ionic gelation, with formulation parameters optimized using DoE. This study investigated the anti-asthmatic efficacy of EUGCNPs (10 mg/kg) in an ovalbumin-induced allergic asthma model in Balb/c mice, focusing on their regulatory effects on NF- κ B p65, MAPK p38, and HDAC1. Histological assessments (H&E, Masson's trichrome), immunofluorescence, and ELISA-based cytokine quantification (IL-13, IL-4, IL-5, TNF- α) were performed. Metabolomic profiling of BALF and lung tissues highlighted metabolic disruption associated with OVA, including alterations in lipid, amino acid, and energy pathways. Oxidative stress markers (MDA, GSH, SOD, CAT) and biochemical indices (NO, ALT, AST, creatinine) were evaluated. Molecular docking and MD simulations provided additional mechanistic insights. EUGCNPs, measuring 50–200 nm, demonstrated enhanced dispersibility attributed to electrostatic hydrogen bonding, as confirmed by SEM and TEM. Treatment restored key metabolites dysregulated by OVA-induced disturbances in amino acid, lipid, and energy metabolism, and markedly reduced the overexpression of HDAC1, MAPK p38, and NF- κ B p65. The restoration of oxidative stress markers and biochemical parameters indicates that EUGCNPs effectively mitigate OVA-induced oxidative injury and systemic toxicity, thereby preserving redox balance and protecting against metabolic and organ dysfunction in allergic airway inflammation. Overall, the findings suggest that EUGCNPs attenuate asthma severity and airway inflammation through the downregulation of HDAC1, MAPK p38, and NF- κ B p65 in an ovalbumin-induced asthmatic mouse model.

Metabolic Engineering of Potato (*Solanum Tuberosum* L.) to Enhance Vitamin B₆ Accumulation and Abiotic Stress Tolerance through Overexpression of *PDX1.3* And *PDX2* Genes

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Vitamin B₆ is an essential metabolic cofactor required for cellular function, yet humans cannot synthesise it endogenously and depend on plant-based diets. Potato (*Solanum tuberosum* L.), a globally important staple crop, offers an ideal target for vitamin B₆ biofortification. This study aimed to enhance vitamin B₆ content and stress resilience in potato through metabolic engineering.

A metabolic engineering approach was employed to co-express *PDX1.3* from *Brassica juncea* and *PDX2* from *Arabidopsis thaliana* in potato using *Agrobacterium tumefaciens*-mediated transformation. Putative transgenic lines were validated through PCR, Southern blotting, and real-time qPCR, while vitamin B₆ accumulation was quantified using chromatographic analysis.

Transgenic potato tubers exhibited a 170–240% increase in vitamin B₆ content compared to controls. Co-expression of *PDX1.3* and *PDX2* significantly enhanced tolerance to salinity stress (50–200 mM NaCl), accompanied by elevated antioxidant enzyme activities. These findings establish *PDX* gene pyramiding as an effective strategy for developing nutritionally enriched, climate-resilient potato cultivars.

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.

Engineering Photoresponsive Iron-Nanozymes for Controlling Bacterial Growth and Enhanced Plant Growth

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The discharge of synthetic dyes from textile industries represents a major environmental concern due to their aesthetic impact on aquatic ecosystems. Crystal violet, a triphenylmethane dye, is particularly problematic due to its complex structure, high chemical stability, and resistance to natural biodegradation processes. Prolonged exposure to CV has been associated with ecological imbalance and microbial toxicity in water systems. Nowadays, nanoparticle-based remediation strategies have gained attention due to their high surface area and catalytic efficiency. However, concerns related to nanoparticle toxicity, ecological persistence, and unintended disruption of beneficial microbial communities hinder their sustainable deployment. The objective of this study is to synthesize iron nanoparticles (FeNP) using a cost-effective approach, enhance the nanozyme-like and photoresponsive properties of iron nanoparticles to incorporate photo responsiveness in order to regulate the bacterial growth against pathogens and phytotoxicity of the nanoconjugates using *Vigna radiata*.

FeNPs were synthesized via a co-precipitation method and subjected to sonoprocessing treatment, which introduced surface grooves as catalytic active sites. Structural, morphological, and physicochemical characterization was performed using X-ray diffraction (XRD), scanning electron microscopy (SEM), zeta potential analysis, Fourier transform infrared spectroscopy (FTIR), and UV–visible spectroscopy. The nanozyme-like catalytic activity and antibacterial activity was assessed against *Pseudomonas aeruginosa*. Phytotoxicity and growth compatibility were evaluated using seed germination and growth assays in *Vigna radiata*.

These structural modifications resulted in significantly improved nanozyme-like catalytic activity and efficient photo activation under ambient light conditions. The FeNP suggested rapid and efficient dye degradation even under ambient light conditions. Under white LED irradiation, the FeCV system exhibited strong photodynamic activity, leading to complete eradication of *Pseudomonas aeruginosa* in the planktonic phase highlighting the light-dependent mechanism. The enhanced performance of the sonoprocessed FeNPs is attributed to increased surface defects and active sites generated during sonication, which facilitate improved dye adsorption, reactive oxygen species generation, and catalytic turnover.

Green Fabrication of Manganese Oxide Nanoparticles & its Application in Mitigating Antimicrobial Resistance and Environmental Toxicity

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The rapid rise of antimicrobial resistance (AMR) and increasing environmental pollution necessitate sustainable and eco-friendly technological solutions. Nanotechnology offers promising alternatives, particularly through green synthesis approaches that minimize toxic by-products. This study aims to develop an environmentally benign method for synthesizing manganese oxide nanoparticles (MnO₂ NPs) using *Cordia myxa* fruit extract, a medicinal plant rich in bioactive phytochemicals that act as natural reducing and stabilizing agents. The work further explores the multifunctional potential of the biosynthesized MnO₂ NPs against multidrug-resistant (MDR) bacteria and organic pollutants, integrating green chemistry with biomedical and environmental applications.

MnO₂ nanoparticles were synthesized using aqueous *Cordia myxa* fruit extract through a green synthesis process. The synthesized nanoparticles were characterized by UV–visible spectroscopy to assess optical properties, transmission electron microscopy (TEM) for morphology and particle size analysis, and Fourier-transform infrared spectroscopy (FTIR) to identify functional groups involved in nanoparticle stabilization. Antibacterial activity against MDR bacterial strains was evaluated using well diffusion, minimum inhibitory concentration (MIC), minimum bactericidal concentration (MBC), time-kill kinetics, protein leakage, and propidium iodide (PI) uptake assays. Biofilm inhibition, catalytic dye degradation, and antioxidant activities were also assessed.

UV–Vis spectroscopy confirmed nanoparticle formation, while TEM analysis revealed well-dispersed, spherical MnO₂ NPs with sizes ranging from 20–50 nm. FTIR spectra indicated the presence of phenolic and carbonyl functional groups responsible for nanoparticle stabilization. The biosynthesized MnO₂ NPs exhibited strong antibacterial activity against MDR strains, with notable efficacy against *Bacillus cereus* (MIC: 0.60%; MBC: 1.20%) and *Escherichia coli* (MIC: 0.62%; MBC: 1.25%). Concentration-dependent inhibition, complete bactericidal activity at 2 MIC, membrane disruption, and 90.86±2.50% biofilm inhibition were observed. Additionally, MnO₂ NPs efficiently degraded Congo red dye within 30 minutes in NaBH₄ medium and demonstrated significant antioxidant activity in DPPH and FRAP assays. These findings highlight *Cordia myxa* mediated MnO₂ NPs as a sustainable nanoplatform for combating MDR pathogens and environmental pollutants.

A Novel Host Defence Mechanism against Viral Proteases

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ISG15 is a ubiquitin-like modifier that is upregulated in response to a wide range of pathogens, including viruses. Over the past several years, numerous studies have delineated the roles of ISG15 in host antiviral responses, both in its free (unconjugated) form and in its conjugated form, where ISG15 is attached to substrate lysine residues through ISGylation. To antagonize ISG15-mediated host immune responses, viruses have evolved specialized proteins that facilitate immune evasion. Furthermore, despite the structural and mechanistic similarities between ISG15 and ubiquitin, and between ISGylation and ubiquitination, no studies to date have reported cross-talk between these two pathways and their potential role in host defence.

Here, we report that ISG15 itself can serve as a substrate for ubiquitination by multiple ubiquitin E3 ligases. We demonstrate that ubiquitination of ISG15 blocks its recognition by a viral protease, a key enzyme that counteracts host immunity. Although the viral protease fails to recognize ubiquitinated ISG15, the modified protein remains a substrate for a human deubiquitinase.

Using crystal structures, together with supporting biochemical and biophysical analyses, we reveal an intriguing protective mechanism in which ubiquitin folds onto a critical interaction surface of ISG15 that is required for viral protease binding. Overall, our findings uncover a novel mechanism of ISG15 protection from viral proteases, with potential implications for therapeutic strategies against viral infections.

Inhibitory Activity of Polyphenolic Compound Extracted From *P. Betel* and *T. Aestivum* with Hecpidin for Iron Deficiency Anemia: An in-Silico Approach.

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Iron deficiency anemia is a widespread nutritional disorder caused by impaired iron absorption and dysregulation of iron homeostasis. Hecpidin, a peptide hormone, plays a crucial role in controlling systemic iron levels by inhibiting iron export through ferroportin. Elevated hecpidin levels result in reduced iron availability and contribute to iron-restricted anemia. Plant-derived polyphenolic compounds possess therapeutic potential due to their bioactivity and safety. The present study aims to investigate the inhibitory interaction of polyphenolic compounds extracted from *Piper betel* and *Triticum aestivum* with hecpidin using an in silico approach.

The three-dimensional structure of hecpidin was retrieved from the Protein Data Bank, and selected bioactive compounds-catechin, chlorogenic acid, and 2, 4-dihydroxybenzaldehyde were obtained from PubChem. Molecular docking was carried out using AutoDock Tools and PyRx software to analyze binding affinity and interaction patterns. Active site prediction and drug-likeness evaluation were performed using CASTp and Swiss-ADME tools, respectively. Docking results revealed significant binding interactions between all three polyphenolic compounds and hecpidin. Catechin showed the strongest binding affinity, followed by chlorogenic acid and 2, 4-dihydroxybenzaldehyde, indicating effective inhibitory potential. Hydrogen bonding and hydrophobic interactions at key residues suggest possible modulation of hecpidin activity, which may enhance iron availability. These findings highlight the importance of natural polyphenolic compounds as potential hecpidin inhibitors. The study provides a molecular basis for further experimental validation and supports the development of plant-based therapeutic strategies for the management of iron deficiency anemia.

Photo- Modulated Insulin Secretion in Channelrhodopsin-2 Expressing Pancreatic β - Cells

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Diabetes mellitus treatment with conventional insulin therapy is associated with hypoglycemia and long-term complications. Although cell-based therapies are promising, they lack precise, user-controlled insulin release. Optogenetics enables user-controlled regulation of cellular activity, but optimal irradiation parameters for tunable insulin dosing in physiologically relevant 3D systems remain unexplored.

Mouse pancreatic β - cells (MIN6) were stably transfected with Channelrhodopsin-2 (ChR2) and cultured as monolayer and 3D spheroids. Following all-trans retinal addition, cells were irradiated with 470 nm at 50mW/cm² under continuous and intermittent dark irradiation regime. Light-induced insulin secretion and intracellular Ca²⁺ responses were quantified using ELISA and Fluo-4 AM, respectively.

This study establishes optogenetic stimulation as a tunable strategy for modulating MIN6-ChR2 cells. In monolayer cultures, blue light irradiation at 50 mW/cm² for 10 s elicited maximum insulin secretion, demonstrating the importance of optimized light intensity and exposure duration for effective β -cell activation. The introduction of intermittent dark phases (5 s on/10 s off) further enhanced insulin release by enabling ChR2 recovery and sustained calcium influx. These responses correlated with increases in intracellular calcium, confirming calcium-dependent exocytosis as the primary mechanism underlying photo-induced insulin secretion. When extended to 3D spheroids, Day 4 spheroids (~370 μ m) exhibited the highest insulin secretion under both continuous (~40%) and intermittent (~53%) irradiation. Also, insulin secretion was significantly higher in spheroids than monolayer cultures, underscoring the critical role of enhanced cell–cell communication in coordinating β -cell function. These findings highlight light patterning and spheroid architecture as critical factors of optogenetically regulated insulin secretion from light-responsive β -cell for cell-based diabetes therapies.

Green Synthesis of Mangiferin-Mediated Fe-Cu-Si Nanocomposite and Its Antibacterial Potential Against Biofilm-Forming Bacteria

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In the current clinical environment, the rising prevalence of wound infections caused by biofilm-forming bacteria poses a severe barrier to successful treatment, as biofilms promote microbial resistance and delay healing. The goal of this research is to create a green-synthesized Fe-Cu-Si nanocomposite and assess its antibacterial properties for wound care and infection control applications.

To isolate and analyze bacteria, clinical samples were collected. Mangiferin was extracted from fresh mango leaves using n-hexane and then processed with ethanol and distilled water for plant extract preparation. This extract was utilized in the green synthesis of Fe-Cu-Si nanocomposite, which was then evaluated for antibacterial activity against pathogenic strains.

The results showed that the synthesized mangiferin-mediated iron-copper-silica nanocomposite was successfully stabilized using chitosan. Chitosan binding enhanced the nanocomposite stability, dispersion, and functional effectiveness, allowing better interaction with microbial cells and biofilms. The nanocomposite showed clear zones of inhibition against pathogenic and biofilm-forming bacterial strains, indicating potent antibacterial action and biofilm-disruptive activity. The nanocomposite demonstrated its potential to combat persistent and drug-resistant diseases by effectively reducing bacterial proliferation and hindering the biofilm formation. These findings demonstrate the importance of nanocomposite-based antibacterial system in treating infections linked to biofilms. The synthesized nanocomposite has excellent potential for application in healthcare sectors like wound care, antimicrobial coatings for medical devices, oral and dental treatments targeting plaque-forming bacteria, and other biomedical surfaces prone to microbial accumulation because of its eco-friendly synthesis and strong antimicrobial performance.

Nup133 Contributes to Neuronal and Muscle Development Homeostasis Through Regulations on Notch-Delta Pathway

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A multitude of nucleoporins (Nups) assemble to form the nuclear pore complex (NPC), which mediates essential nucleocytoplasmic transport. Beyond transport, recent studies have linked several Nups to gene regulation, signalling, and development, highlighting their importance in cellular and organismal homeostasis. In humans, mutations in Nup133 are associated with disorders characterised by reduced brain size and renal failure, while studies in zebrafish and mice demonstrate its requirement for brain development and neuronal differentiation. The objective of this work is to define how Nup133-dependent nuclear gatekeeping regulates access of key signalling effectors and how selective transport defects disrupt downstream transcriptional programs contributing to impaired brain and organ development.

To investigate the functional role of Nup133, *Drosophila melanogaster* was used as a genetically tractable model. A Nup133 null mutant was generated using CRISPR–Cas9, and organism-wide as well as tissue-specific consequences of Nup133 loss were examined across neural, muscular, and epithelial tissues. Notch pathway activity and tissue development were analysed using reporter-based assays, high-resolution immunofluorescence, confocal microscopy, and behavioural locomotion assays.

Loss of Nup133 results in early developmental arrest and failure to progress beyond larval stages, reflecting features associated with impaired brain development. RNAi-mediated depletion of Nup133 reveals additional roles in later stages, including defective thoracic muscle patterning and pupal lethality due to eclosion failure. Mechanistically, Nup133 loss specifically impairs nuclear import of the Notch intracellular domain (NICD), causing its aberrant cytoplasmic retention and failure to activate downstream transcriptional programs. Consistently, the Notch target transcription factor Cut fails to localise to the nucleus. These signalling defects lead to severe developmental consequences, including impaired optic lobe growth, locomotor dysfunction, abnormal flight muscle organisation, neuromuscular junction overgrowth, synaptic disorganisation, and microtubule instability. Together, these findings identify Nup133 as a critical regulator of Notch-dependent differentiation and link nuclear transport defects to disease-relevant neurodevelopmental and neuromuscular pathology.

CircEPSTI1 Regulates miR-942-5p-SERPINE1-AKT1 Axis to Enhance Dengue Infection and is Suppressed by Tiplaxtinin

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Dengue virus is an emerging global health threat due to the increased outbreaks throughout the world. Circular RNAs (single-stranded, covalently closed RNAs, formed through back-splicing) have recently been identified as crucial regulators of gene expression. They are highly stable and have shown to have higher diagnostic and therapeutic potential.

Several methods like RNA isolation, qPCR, Luciferase assay, Fluorescent in situ hybridization, isolation of PBMCs, RNA sequencing analysis, Digital PCR, RNA immunoprecipitation, Biotin pull down assay, Enzyme linked immunosorbent assay, immunoblot analysis, confocal microscopy, flow cytometry were used to find out the role of circEPSTI1 in DENV infection.

In this study, circEPSTI1 induction was observed in peripheral blood mononuclear cells (PBMCs) and plasma of dengue patients. The induction of circEPSTI1 is interferon-dependent and enhances DENV infection by sponging the expression of miR-942-5p. The antiviral role of miR-942-5p is mediated by bidirectional inhibition through targeting conserved genomic sequences of the DENV genome of different subtypes across NS1, NS3, and NS5 and the host AKT1 signaling pathway. RNA-seq analysis of DENV-infected circEPSTI1 knockdown A549 cells identified SERPINE1 and AKT1 signaling pathways to be dysregulated significantly. circEPSTI1 relieves the inhibition of miR-942-5p over DENV genomic RNA and the host SERPINE1 to activate AKT1 signaling. The activation of AKT1 signaling facilitates cell survival and enhances DENV replication. The expression of SERPINE1 and circEPSTI1 was upregulated in Dengue patients, and pharmaceutical inhibition of SERPINE1 through Tiplaxtinin inhibits the DENV replication by reducing the expression of circEPSTI1. Overall, our result demonstrates the therapeutic potential of Tiplaxtinin by targeting the circ-EPSTI1-miR-942-5p-SERPINE1-AKT axis in dengue treatment.

Interpretable Histomorphometric Profiling Linking Multi-scale Histology to Structured Nuclear Morphometrics

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Accurate nuclei instance segmentation in haematoxylin and eosin whole-slide images is essential for quantitative computational pathology because nuclear shape, size, and spatial arrangement play a central role in diagnosis and prognosis. However, dense cellular packing, stain variability, and tissue heterogeneity continue to limit the reliability of automated pipelines. Furthermore, it remains unclear whether current segmentation outputs translate into biologically plausible morphometric representations for downstream clinical discovery.

Therefore, we present a hierarchical, region-guided framework that integrates tissue compartment localisation with robust nuclei instance segmentation. By explicitly separating touching nuclei and computing high-dimensional descriptors of nuclear morphology and chromatin texture, we generate comprehensive patch-level histomorphometric profiles. We demonstrate that these profiles exhibit structured clustering, reflecting consistent and morphologically distinct nuclear phenotypes. To interpret these morphometric spaces, we employ SHapley Additive exPlanations (SHAP)-based feature attribution to identify the specific descriptors driving class-discriminative boundaries.

Our framework effectively bridges tissue-level context and nuclear-level morphology to produce biologically meaningful and interpretable phenotypes. Grounding predictions in explainable histomorphometric features, it provides a transparent, morphology-driven foundation for reliable discovery in computational pathology.

Third Generation Nanopore Sequencing for Detection of *Salmonella* Typhi *Enterica* Spiked in Blood by Shotgun Metagenomics

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Salmonella enterica (*S. Typhi*) is the major cause of typhoid which is not only public health problem but also belongs to risk group 2 bio-threat agent. Nanopore sequencing has emerged as high-throughput, less labour intensive and performs real time analysis. We aimed to detect *S. Typhi* (lower cfu/ml) spiked in blood by nanopore (ONT) shotgun metagenomics (mNGS).

S. Typhi was spiked in blood, gDNA extracted and its validation was done by PCR. Thereby, (mNGS) was performed to detect *S. Typhi* wherein, native barcoding library preparation method was used. MinIon sequencer performed sequencing and data analysis was done by commander tool which resulted in taxonomic profiling of *S. Typhi* in lesser cfu/ml.

Whole genome metagenome analysis was performed using nanopore technology to detect abundance of species present in spiked blood. For this, extraction of gDNA from *S. Typhi* spiked in blood was carried out using manual method which showed intense DNA bands. Validation for the presence of *S. Typhi* was done by PCR using *viaB* gene specific primers which resulted in 599 bp amplicons. Prior to sequencing, library preparation was performed by native barcoding library method. MinIon sequencer performed real time sequencing and data analysis was done by commander 2.0. This aided in taxonomic profiling of *S. Typhi* in lesser cfu/ml wherein, 96% abundance of *S. Typhi enterica* was observed in 10^5 cfu/ml amongst *Salmonella* genus and that in 10^3 cfu/ml of *S. Typhi* was 82%. In this study, detection of spiked bacterial bio-threat agent was achieved by taxonomic profiling up to species level. Moreover, this specific and timely detection can lead to proper treatment of the victims. Our research work proves to be significant and holds importance as it harnesses the potential of long read sequencing technology to detect *S. Typhi enterica* at 10^3 cfu/ml spiked in blood.

Toll/IL-1 Receptor Domain-Containing Adaptor Protein Plays A Crucial Role in Macrophage-Mediated Hepatic Stellate Cell Activation in Alcoholic Liver Disease

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Objectives and Background- Alcoholic liver disease (ALD) is marked by chronic liver injury and progressive accumulation of extracellular matrix (ECM), ultimately leading to fibrosis. A key driver of fibrosis is the activation of hepatic stellate cells (HSCs), largely influenced by inflammatory signals from immune cells—particularly macrophages. This study explores the specific signalling mechanisms in macrophages that contribute to HSC activation in response to alcohol exposure, with the aim of identifying new therapeutic targets.

Materials and Methods- To mimic the disease condition, THP-1-derived macrophages were treated with ethanol and lipopolysaccharide (LPS), and LE. Cytokine expression was assessed by RT-PCR. Immunoblotting and immunostaining were performed to analyse the TIRAP activation. Further macrophage-specific TIRAP-mediated HSCs activation was confirmed by RT-PCR and immunoblotting of fibrotic markers in the response to wild-type and TIRAP-silenced macrophages.

Finding and Discussion- Macrophage activation was indicated by increased expression of pro-inflammatory and fibrogenic factors, including IL-1 β , TNF- α , IL-6, TGF- β , and PDGF- α . Signalling analysis revealed heightened phosphorylation of TIRAP (Toll/IL-1 receptor domain-containing adaptor protein), along with activation of downstream MAPK pathways (p38, ERK, JNK) and NF- κ B. The conditioned media from these activated macrophages were applied to HSC cultures, resulting in elevated levels of fibrotic markers, including α -smooth muscle actin (α -SMA) and collagen, confirming HSC activation. Importantly, silencing TIRAP in macrophages significantly reduced the expression of these markers in HSCs, suggesting a key role for TIRAP in driving fibrogenesis. Overall, these findings underscore the importance of TIRAP-mediated signalling in macrophages as a central mechanism in alcohol-induced liver fibrosis and propose macrophage TIRAP as a promising therapeutic target in ALD.

Ecofriendly Bioremediation of the Poultry Feather Waste Using Surfactant-Stable *Bacillus Licheniformis* Keratinase

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Keratin-rich wastes such as chicken feathers offer significant environmental challenges but represent an abundant substrate for value-added enzyme production. This study aimed to produce and characterize a surfactant-stable keratinase from a newly isolated soil bacterium, *Bacillus licheniformis* NKPG, with a focus on its suitability for detergent industry applications.

Keratinase production was optimized using Response Surface Methodology (RSM), employing chicken feathers as the sole carbon and nitrogen source. The enzyme was characterized for its biochemical properties, stability, and interaction with surfactants and detergents. Structural and hydrolysis analyses were performed using XRD, FTIR, NMR, UV-Vis spectroscopy, and molecular docking studies.

The keratinase exhibited optimal activity at 60°C and pH 9.0 and was identified as a serine protease. The keratinase activity was enhanced by metal ions (Ca^{2+} , Mg^{2+}), β -mercaptoethanol, and surfactants (Tween 20, Tween 80 & Triton X 100). Follow-up of hydrolysis events by XRD demonstrated a reduction in the total crystallinity while the spectroscopic analyses (FTIR, NMR & UV-Vis) confirmed the feather solubilization and release of amino acids. The keratinase showed a marked stability against various surfactants and commercial detergents. Molecular docking studies revealed distinct interaction mechanisms, with SDS, Tween 20, and Tween 80 binding directly to the keratinase active site, while Triton X-100 and urea imparted regulatory effects through allosteric modulation. These findings underscore the keratinolytic potential of *B. licheniformis* NKPG and its potential in detergent industry. Importantly, the feather hydrolysate generated during enzymatic degradation was rich in soluble peptides and amino acids and was successfully utilized as an alternative, low-cost peptone source for the cultivation of bacterial and fungal species in microbiological media.

HIV-1 Virions Selectively Package Circesynt2 to Sculpt an Actin Scaffold that Constrains Egress

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Retroviruses such as HIV-1 package both viral and host RNAs, yet whether circular RNAs (circRNAs) enter virions has remained unknown. Here, we capture the HIV-1 RNA packageome and show the evidence that circRNAs represent a previously unrecognized class of selectively encapsidated host RNAs. Using nanopore sequencing of purified virions, we identify fourteen host-encoded circRNAs that are packaged and focus on the abundant species circESYT2. Expression of HIV-1 Gag alone is sufficient to drive circESYT2 incorporation into virus-like particles, indicating that circRNA incorporation is an intrinsic property of the assembly machinery. Proximity-labeling, mass spectrometry and network analysis of the proteins reveal that circESYT2 is embedded in a filamentous cytoskeleton and interacts predominantly with actin, and functional perturbation in a T-cell line shows that circESYT2 depletion destabilizes actin assembly, reduces actin incorporation into virions and enhances viral egress. Extending this analysis to other retroviruses demonstrates that circESYT2 is more efficiently packaged by murine leukaemia virus than by HIV-1, whereas foamy virus excludes it, indicating virus-specific selectivity in circRNAs capture. These findings suggest circRNAs as bona fide components of retroviral particles and uncover a host RNA–cytoskeleton axis in late replication as an unanticipated layer to host–virus crosstalk.

Silk Nanoparticles for Combinational Anti-Cancer Chemo and Photothermal Therapy

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Cancer is one of the lethal diseases in the world, whereas conventional monotherapy in cancer treatment has several drawbacks. Therefore, currently there is an increasing interest in combinational therapy, which integrates two or more treatment methods for the eradication of tumors. In this study we have fabricated biocompatible silk fibroin nanoparticles coloaded with Doxorubicin (DOX) a chemotherapeutic drug and Indocyanine Green (ICG), FDA approved near-infrared (NIR) photothermal agent to develop a combinational anti-cancer chemo and photothermal platform for solid cancer treatment. The ICG-DOX coloaded silk nanoparticles (IDSNPs) (~98%) has higher ICG encapsulation, induced by DOX-mediated J-aggregation of ICG as compared to only ICG-loaded nanoparticles (ISNPs) (~20%). Upon 808 nm laser irradiations, IDSNPs show potent photothermal ability since ICG can efficiently convert light energy into localized heat, inducing photothermal ablation of cancer cells and enhancing DOX penetration and cytotoxicity. In vitro cell cytotoxicity assays using HEK293 (Human embryonic kidney cells), MCF-7 (breast cancer cells), and HeLa (cervical cancer cells) cells demonstrated that IC₅₀ value of IDSNPs were found to be significantly lower than that of free DOX. This indicates that IDSNPs are more effective in inhibiting cell growth at lower concentrations. Moreover, IDSNPs exhibited preferential cellular uptake only in 6 h, which enhances their cytotoxic potential. IDSNPs upon laser irradiation significantly decreased the cell viability compared to either free DOX or free ICG alone. When cells were incubated for 12 h post laser irradiation almost complete ablation of tumor was observed which indicates the enhanced penetration of DOX post laser irradiation. This highlights the potential of IDSNPs for use in cancer therapy, as they not only improve the delivery and efficacy of chemotherapeutic agents but also enhance the therapeutic outcomes through synergistic effects of chemo and photothermal therapy.

Molecular Identification and Screening of Multidrug-Resistant Bacterial Species Targeted for Nano Antibiotics with Special Reference to Beta-Lactam Group

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World Health Organization (WHO) has identified Multidrug-resistant (MDR) pathogens as a critical global health concern. They belong to ESKAPE (*Enterococcus Faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Pseudomonas aeruginosa*, *Enterobacter* spp.) group. These pathogens pose a serious threat to public health due to their increasing ability to survive against the multiple classes of antibiotics. In recent years, MDR bacteria have shown a rapid rise in resistance against β -lactam group of antibiotics, which are widely used in clinical practice, so our objective is isolation and identification of MDR up to molecular level and the evaluation the role of nano antibiotics.

The study is focused on isolation of MDR bacteria from the hospital environment and screened them based on their antibiotic-resistant profiling. We have selected two pure cultures showed complete resistance to Amoxicillin and Cefuroxime. Morphological and biochemical assays were employed for phenotypic characterization, while molecular characterization (16s rRNA sequencing) was conducted to confirm the presence of bacterial strains.

Staphylococcus stutzeri JP44SK53 and *Pseudomonas stutzeri* (VIT-DSJ) were found as MDR. To address this growing challenge of antimicrobial resistance, a novel therapeutic approach was performed in the form of antibiotic-based nano-formulations. We have found significant zone of inhibition ($18\pm 1\text{mm}$ and $20\pm 1\text{mm}$) for *staphylococcus homonis* and *pseudomonas stutzeri* respectively when compared with a standard deviation (SD). The results of the study were significantly showed antimicrobial activity with nano antibiotic. The study based on nano antibiotic emphasizes the urgent need for alternative therapeutic strategies to combat MDR pathogens and supports the potential application of nanotechnology in modern antimicrobial therapy.

An Uncharacterized Domain Within the N-Terminal Tail of Histone H3 Regulates the Transcription of *flo1* via Cyc8

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Yeast flocculation is mediated by cell surface flocculin proteins encoded by subtelomeric *flo* genes. *flo* gene transcription is governed by antagonistic activities of the Swi/Snf co-activator and Tup1–Cyc8 repressor complexes. Although histone hyperacetylation is a well-established regulator of repressor–activator dynamics at *flo* loci, the intrinsic and spatial contribution of histone H3 and H4 N-terminal residues to precise *flo1* transcriptional control remains poorly understood.

To address this gap, histone H3 and H4 tail truncation mutants were screened for altered flocculation phenotypes. Selected mutants were further analysed for changes in *flo* gene expression using quantitative PCR. Global alterations in histone modifications were assessed by immunoblotting, while the promoter specific effects on chromatin architecture, transcription factor recruitment, and nucleosome positioning were examined using chromatin immunoprecipitation.

Our analysis identified a previously uncharacterized region within the histone H3 N-terminal tail, encompassing amino acids 17–24, as a critical regulator of *flo1* and *flo5* transcription. Deletion of this stretch significantly elevated *flo1* and *flo5* expression compared to wild-type H3, indicating a transcription-restrictive role. This upregulation correlated with reduced Cyc8 association and decreased nucleosome occupancy at the *flo1* upstream regulatory region, suggesting that H3 17–24 maintains a chromatin environment permissive for Cyc8-mediated restraint. Notably, Cyc8 association occurs independently of Tup1 and is facilitated by the histone deacetylase Hda1, revealing a previously unrecognized regulatory role beyond the classical Tup1–Cyc8 complex. These findings uncover a chromatin-based mechanism in which a discrete H3 tail sub-domain modulates transcription factor occupancy and *flo* gene output. Importantly, as yeast flocculation is industrially and environmentally relevant, epigenetic modulation of histone tails offers a potential strategy to enhance flocculation without permanent genetic modification, providing an alternative to conventional strain engineering that can compromise growth or cellular health.

PANK4 Dysregulated in Metabolic Diseases Plays an Essential Role in TLR7/9-Mediated Antiviral Innate Immunity via Targeting UNC93B1

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Innate immune responses are closely linked to cellular metabolism, yet the molecular mechanisms connecting metabolic reprogramming and antiviral immunity remain poorly understood. This study identifies PANK4, a non-canonical pantothenate kinase (pseudo kinase) with phosphatase activity, as a novel regulator of RNA virus, including influenza virus (IAV), pathogenesis, particularly under metabolically challenged conditions.

In this study IAV infection models were employed in human cells with modulation of PANK4 expression. Viral replication, glucose uptake, and glycolytic activity were assessed using imaging techniques, RT-PCR, and western blotting. Protein–protein interactions were examined through co-immunoprecipitation, while downstream innate immune signalling was analysed by gene and protein expression studies.

We demonstrated that IAV infection, in combination with pantothenic acid (PA), significantly induces PANK4 expression. PANK4 promote viral replication by enhancing glucose uptake and glycolytic flux. Elevated PANK4 expression was also observed under metabolic disease conditions, suggesting a metabolic vulnerability exploited by the virus. Silencing/Loss of PANK4 markedly restricted viral replication, which is accompanied by increased TLR7 expression, suppression of key glycolytic regulators, and strengthened antiviral immune responses. Mechanistically, PANK4 directly interacts with UNC93B1 and dephosphorylates phosphorylated UNC93B1 through its intrinsic phosphatase activity, thereby modulating TLR7-dependent innate immune signalling. Furthermore, influenza viral proteins NS1 and PB1 hijack PANK4 to enhance viral replication and facilitate immune evasion. Collectively, these findings uncover PANK4 as a critical metabolic–immune checkpoint that links CoA biosynthesis, glycolysis, and antiviral defense, highlighting its potential as a therapeutic target in viral infections, particularly in metabolically compromised conditions such as Hyperglycaemia and obesity.

Encoding the TB Genome for ML: Representation-driven Prediction of Antimicrobial Resistance in *Mycobacterium Tuberculosis*

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Antimicrobial resistance (AMR) in *Mycobacterium tuberculosis* is a significant threat to global health, often outpacing traditional control efforts. While Whole-Genome Sequencing (WGS) offers a faster alternative to slow phenotypic drug susceptibility testing (pDST), a major hurdle remains: data encoding. Most research focuses on fine-tuning machine learning (ML) models, yet the way genomic data is represented for these models is often the true bottleneck. The objective of this study is to identify the most effective genomic data representations for clinical use by analyzing 100 *M. tuberculosis* WGS samples paired with pDST metadata and prioritizing feature engineering over model architecture.

This study utilized 100 *M. tuberculosis* sequences from the CRyPTIC database, equally representing rifampicin-resistant and pan-susceptible traits. Following quality control with fastp and BWA-MEM2 alignment to the H37Rv reference, variants were identified via deep learning and strictly filtered. These variants were functionally annotated to target resistance drivers and converted into genetic encoding matrices using Python. Finally, six machine learning architectures were benchmarked via cross-validation and SHAP analysis to link specific genetic features to model performance.

Our comparison revealed that genomic data representation is a more critical determinant of prediction performance than the ML algorithm choice. For rifampicin, features restricted to WHO-catalogued amino acid changes achieved near-perfect classification (AUC \approx 1.0). However, other drugs required more complex representations. Chi-squared selection identified resistance-linked variant positions, while sample-level extraction captured aggregate mutation metrics to enable multimodal prediction at the isolate level. This suggests a drug-dependent hierarchy where validated variants provide a maximum signal for well-characterized resistance, while broader encodings are necessary for complex phenotypes. SHAP analysis confirmed model interpretability by identifying established resistance hotspots like rpoB S450L. Future efforts include validation on diverse clinical cohorts and the development of an on-premise software tool for frontline labs. This pipeline aims to enable rapid, targeted therapy and strengthen global drug stewardship to accelerate TB elimination.

An Intelligent Hybrid Deep Learning Framework for Strengthening Pneumonia Diagnosis and Public Healthcare Using Chest X-Ray Images

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Pneumonia remains one of the leading causes of preventable deaths worldwide, particularly affecting children, elderly individuals, and populations in rural and resource-limited regions. Timely and accurate diagnosis plays a crucial role in saving lives; however, the shortage of trained radiologists and increasing clinical workload often delay diagnosis. The objective of this study is to develop a reliable and accessible artificial intelligence-based diagnostic system that can support healthcare professionals and strengthen early pneumonia detection using chest X-ray images.

This research presents a hybrid deep learning framework that integrates ConvNeXt, a powerful convolutional neural network, with the Swin Transformer, a modern vision transformer architecture. ConvNeXt focuses on identifying critical local lung patterns, while the Swin Transformer captures broader spatial and structural information across the X-ray image. To ensure that medically important features are emphasized, Squeeze-and-Excitation attention is incorporated. Bayesian Optimization is employed to automatically select optimal model parameters, improving robustness and reducing human intervention. The model is trained and tested on a standard chest X-ray dataset consisting of Normal and Pneumonia cases.

The proposed framework achieved an accuracy of 99.76%, outperforming widely used deep learning models such as DenseNet-121 and EfficientNet. High sensitivity for pneumonia cases and strong precision for normal cases, supported by ROC-AUC values between 0.97 and 1.00, demonstrate the model's reliability. Beyond technical performance, this work highlights the societal importance of artificial intelligence in healthcare by offering a fast, cost-effective, and scalable diagnostic aid. The proposed system has the potential to support frontline clinicians, reduce diagnostic delays, and improve healthcare outcomes, particularly in underserved and remote communities.

Epitope-Based Vaccine Design Targeting Nipah Virus Fusion Protein: An Immunoinformatics Study

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Nipah virus (NiV) is an emerging zoonotic pathogen associated with severe respiratory illness and encephalitis, with case fatality rates as high as 75%. Recent outbreaks in India underscore the urgent need for preventive measures, as there are currently no approved vaccines or targeted therapeutics. Epitope-based vaccine design offers a precise alternative to traditional methods by focusing on immunodominant viral regions to trigger specific immune responses. This study aims to design a multiepitope vaccine targeting the NiV fusion (F) protein using an immunoinformatics approach. The primary objective was to identify highly conserved B-cell and T-cell epitopes capable of eliciting robust, broadly protective immunity across diverse populations.

A total of 66 global NiV isolates were retrieved from different databases and comprehensive immunoinformatics workflow was applied using different online tool, including BepiPred 2.0, ABCPred, and BCPred for B-cell epitope prediction, and NetMHCpan-EL alongside NetMHCIIpan-4.1 for T-cell epitope prediction. Predicted epitopes were screened for antigenicity via VaxiJen, allergenicity via AllerTOP, and toxicity via ToxinPred. Selected epitopes were then integrated into the Sa antigenic site of an Influenza A/Puerto Rico/8/1934 (PR8) hemagglutinin (HA) backbone using suitable linkers like EAAK and GPGPG. Molecular docking via the HDOCK server was performed to evaluate binding affinities of recombinant HA protein with HLA alleles and human Toll-like receptors TLR2 and TLR4.

Consensus analysis identified LGSVNYNSEGIAIGPP (B-cell), FISFIIVEK (MHC-I), and SEWISIVPNFILVRN (MHC-II) as the most potent epitopes. These determinants demonstrated exceptional global population coverage, reaching 89.50% for MHC Class I. The finalized Epi_HA3 construct exhibited strong structural complementarity. Also, highly negative energy values in docking with TLR2 and TLR4, confirming its potential to trigger innate immune signaling. This study highlights the utility of the PR8 influenza backbone as a modular, repetitive scaffold for presenting foreign epitopes. The findings establish a crucial foundation for a safe, non-infectious, and bivalent vaccine template that addresses the critical gap in Nipah virus countermeasures.

A Versatile Pseudovirus Platform for Dissecting Chandipura Virus Entry, Neutralising Antibody Response, and Vaccine Evaluation

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Chandipura virus (CHPV) is a re-emerging neurotropic rhabdovirus associated with acute encephalitis outbreaks, particularly in paediatric populations. Owing to its high pathogenicity, the availability of safe and scalable experimental systems to study CHPV entry and neutralisation remains limited. The present study aimed to develop a pseudovirus system that accurately mimics CHPV entry while enabling high-throughput applications.

A replication-deficient vesicular stomatitis virus backbone lacking glycoprotein gene (VSV-ΔG) and encoding teal fluorescent protein (TFP) was pseudotyped with the Chandipura virus glycoprotein (CHPV-G). High-titer pseudovirus production was optimised in different cell lines, including HEK293T cells, BHK-21, and SKNSHSY5Y cells. The viral particles were characterised using fluorescence-based infectivity assays, neutralisation tests, and mass spectrometry to confirm CHPV-G incorporation. Host entry dependency was assessed using receptor-specific inhibition approaches.

The CHPV pseudovirus achieved high titers of approximately 10^8 fluorescent focus units per millilitre and exhibited strong thermostability, as demonstrated by sustained infectivity following multiple freeze-thaw cycles. Specificity was confirmed by selective neutralisation with anti-CHPV serum, with no cross-neutralisation observed against VSV-G pseudotypes. Importantly, the pseudovirus closely recapitulated wild-type CHPV entry characteristics, including a comparable neutralisation profile and dependence on the host entry factor low-density lipoprotein receptor 1 (LRP1). The platform enabled the development of a robust, high-throughput microneutralization assay and elicited a potent neutralising antibody response in mice following immunisation with heat-inactivated pseudovirus. Collectively, these findings establish the CHPV pseudovirus as a reliable, safe, and scalable biosafety level 2 (BSL-2) tool that bridges basic and translational CHPV research, facilitating receptor studies, antiviral screening, and the evaluation of vaccine and therapeutic candidates.

Investigating the Role of Rer1 in the Maintenance of Protein Homeostasis and Myc-Driven Overgrowth in Developing *Drosophila* Wing Epithelium

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The precise maintenance of tissue homeostasis is essential for the development of a healthy multicellular organism. To protect the growing tissues from harbouring unfit or aberrant cells, multicellular organisms have evolved various tissue-intrinsic mechanisms, one of which is known as "cell competition". In this process, cells with reduced fitness acquire the loser status and are eliminated by the fitter(winner) neighboring cells via contact-dependent cell-cell interactions. In this study, we have explored the role of an ER and cis-Golgi localized protein known as Retention in the endoplasmic reticulum 1 (Rer1) in the competitive survival of the developing *Drosophila* wing epithelial cells. We demonstrate that the loss of Rer1 induces proteotoxic stress, activating the PERK pathway. This activation increases phosphorylated eIF2 α levels, which causes cytotoxicity and the elimination of mutant cells by their neighboring normal cells.

Interestingly, proteotoxic stress is also observed in super-competitor cells such as Myc overexpressing cells, which proliferate at the expense of neighboring wild-type cells. Thus, Myc-driven overgrowth relies on the activation of cytoprotective unfolded protein response (UPR) pathways. Furthermore, we find that Rer1 levels are upregulated in response to Myc overexpression, and this increase in Rer1 provides cytoprotection to Myc-overexpressing cells, thereby supporting their overgrowth. These findings uncover a dynamic interplay between Myc, Rer1, and the unfolded protein response (UPR), highlighting how developing tissues harness stress-response pathways not only to maintain protein homeostasis but also to shape competitive cell behaviors that determine cellular fitness and tissue composition.

Development of Multimodal Microscopic Spectral Imaging System and its Application for Delineation of Breast Cancer

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Temporal-spectral imaging enhances the functionality of conventional microscopy by incorporating both the temporal and spectral information into spatially resolved images. Here, we report the development of a multimodal microscopic system capable of hyperspectral and multi-wavelength time-lapse imaging. The ability of the system was evaluated for delineation of breast cancer using machine learning approaches.

The developed imaging system employs a liquid crystal tunable filter (LCTF) as a spectral decomposition element that offers flexible waveband selection without compromising spatial resolution. It was calibrated and systematically characterized for all domains: spatial, spectral, and temporal. Further, multi-wavelength time-lapse fluorescence images of resected breast tissue were acquired and analyzed.

Multimodality of the developed imaging system was demonstrated through Transmission hyperspectral imaging (THSI) and fluorescence hyperspectral imaging (FHSI) as well as spectral and temporal-spectral scanning modes. Systematic calibration and characterization of the system in the spatial, spectral, and temporal domains ensured its accuracy, reliability, and reproducibility. The linearity of the system response to exposure time and emission intensity further confirmed its suitability for quantitative imaging. Validation experiments conducted on real biological samples and model systems highlight its potential for a wide range of biomedical applications. The performance of the system was evaluated for delineation of cancer margins in resected breast tissue samples. The fluorescence photobleaching characteristics measured via time-lapse fluorescence imaging at multiple wavelength bands were found to be a potential biomarker for breast tissue characterization. Furthermore, the superiority of state-of-the-art machine learning algorithms over the conventional parametric model-based approach was established in semantic image segmentation of interrogated samples.

DRZ-V, a Sulfonamide-Based Small Molecule, Promotes Wound Healing by Modulating TIRAP-Dependent Inflammation and M2 Macrophage Polarization

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Wound healing requires tightly regulated inflammatory responses and timely activation of tissue repair mechanisms. Macrophages play a pivotal role by transitioning from a pro-inflammatory (M1-like) to a reparative (M2-like) phenotype. Impaired macrophage polarization results in prolonged inflammation and delayed healing. This study aimed to evaluate the wound-healing potential of DRZ-V, a sulfonamide-based small molecule, and to investigate whether its effects involve modulation of TIRAP-dependent inflammatory signaling.

Wound healing was assessed using a full-thickness excisional wound model in mice treated topically with DRZ-V. In vitro studies were conducted using RAW 264.7 macrophages and L929 fibroblasts. Macrophage polarization and cytokine expression were analyzed by quantitative real-time PCR. Fibroblast migration was evaluated using a scratch assay with macrophage-conditioned media. Activation of TIRAP and NF- κ B signaling was examined using immunofluorescence staining and immunoblotting.

DRZ-V treatment significantly accelerated wound closure and improved tissue regeneration in vivo. In macrophages, DRZ-V suppressed lipopolysaccharide-induced pro-inflammatory cytokine expression and promoted polarization toward an M2-like phenotype, evidenced by increased expression of Arg1, Fizz1, and Ym1. DRZ-V also restored macrophage-derived pro-repair growth factors, including TGF- β and PDGF. Conditioned media from DRZ-V-treated macrophages enhanced fibroblast migration, demonstrating functional macrophage reprogramming. Mechanistically, these effects were associated with inhibition of TIRAP phosphorylation and reduced NF- κ B activation. Collectively, these findings identify DRZ-V as a promising immunomodulatory agent capable of limiting excessive inflammation and promoting effective tissue repair in inflammation-impaired wound healing.

AdaBioBERT: Adaptive Token Sequence Learning for Biomedical Named Entity Recognition

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Accurate identification of biomedical entities such as diseases, genes, chemicals, and species is essential for knowledge discovery from scientific literature. However, existing named entity recognition systems often struggle with complex multi-token terms and domain-specific ambiguity. This work presents AdaBioBERT, an adaptive biomedical NER framework designed to improve contextual understanding and structured entity extraction.

The proposed approach integrates Word2Vec semantic embeddings with a pretrained BioBERT model and introduces an Adaptive Token-Sequence Loss that combines Cross-Entropy and Conditional Random Field objectives. Biomedical sentences extracted from PubMed Central are used to generate semantic embeddings, which are fused with BioBERT representations. A learnable weighting mechanism dynamically balances token-level prediction and sequence-level coherence during training.

Experimental evaluation on eight benchmark biomedical datasets demonstrates consistent improvements in both macro and micro F1 scores over existing state-of-the-art systems. AdaBioBERT shows strong performance particularly on datasets containing complex multi-token entities, such as disease and anatomical terms. Analysis of the adaptive loss reveals that chemical and gene entities benefit more from token-level learning, while disease-related entities require stronger sequence modeling. These findings highlight the importance of adaptive learning strategies for heterogeneous biomedical text. The proposed framework offers a robust and generalizable solution for biomedical named entity recognition, supporting downstream applications such as evidence synthesis, clinical text mining, and automated knowledge extraction. By combining semantic and contextual representations with adaptive optimization, AdaBioBERT advances reliable biomedical information processing and contributes toward scalable, AI-driven healthcare research.

Mechanistic Insights into Syk Regulation: Molecular Simulations Reveal Loop Dynamics and Mutation-Induced Perturbations

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Spleen tyrosine kinase (Syk) is a central regulator of immune signaling and is implicated in autoimmune disorders, cancer, and neurodegenerative diseases. While Syk studies have largely focused on drug discovery, the molecular regulatory dynamics of Syk and the structural impact of disease-associated mutations remain poorly understood.

We performed microsecond-scale all-atom molecular dynamics and Gaussian Accelerated MD simulations of full-length Syk and its kinase domain to investigate phosphorylated states and mutation-induced dynamics in the P342T, A353T, M450I, S550F, and S550Y variants. Trajectories were investigated using conformational analyses such as deviation and distance-based metrics, free energy surface, network-based methods, and Markov state model approaches, and binding energetics.

Global structural analyses revealed that interdomain B in full-length Syk exhibits increased structural deviation and broader conformational sampling relative to the wild-type protein, accompanied by altered residue-level flexibility. In the P342T and A353T mutants, the central region of the SH2-kinase linker showed a pronounced shift in motion toward the C-SH2 domain, along with increased inter-residue connectivity in interdomain B and different connectivity patterns within the kinase domain. Markov state model analysis identified five macrostates for each full-length Syk system. While the wild type sampled these states relatively evenly, the P342T and A353T mutants preferentially populated a subset of dominant macrostates, indicating mutation-driven reshaping of the conformational landscape. Distance-based analyses further revealed kinase domain mutation-induced alterations in charge-charge interactions within the activation segment. However, the inhibitory efficacy of the control drug fostamatinib remained comparable across systems. Overall, these findings provide mechanistic insight into the dynamic regulation of Syk and establish a framework for future studies and drug design.

Design and Characterization of De Novo Miniprotein Binders Targeting Immune Checkpoint Protein PD-L1

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Cancer is characterized by abnormal cell division and remains one of the leading causes of mortality worldwide. Current treatment strategies including surgery, chemotherapy, radiation, and immunotherapy aim to control disease progression. Among targeted therapies, monoclonal antibodies (mAbs) have shown significant success. However, they face limitations such as high production cost, post-translational modification challenges, limited tissue penetration, and immunogenicity. Miniprotein scaffolds (4–12 kDa) offer an attractive alternative to mAbs due to their small size, fewer secondary structural elements, and improved stability and designability. De novo design of such mini-protein binders with high affinity is an emerging strategy for targeted therapy.

In this study, we utilized RFdiffusion, a generative AI model, to design de novo mini-protein binders targeting the immune checkpoint protein PD-L1. Hotspot residues on PD-L1 were identified based on interactions with a known monoclonal antibody. Binder sequences of 70–80 amino acid long, predominantly α -helical in structure, were computationally designed through RFdiffusion simulation runs, using a predicted aligned error (pAE) score threshold of 5 and a predicted local distance difference test (pLDDT) score of 90. From these simulations, 40 candidate binders were generated, and the top 10 designs (based on pAE and pLDDT) were chosen for experimental validation such as affinity and thermostability.

These binders were gene-synthesized, cloned, expressed, and purified and oligomeric status was evaluated. Circular dichroism (CD) spectroscopy was used to assess secondary structure and thermostability, revealing six binders with high thermostability. Subsequently SPR-based binding assays confirmed that one binder displayed nanomolar affinity toward PD-L1. A crystal structure for the positive miniprotein binder (Gpx41) was solved at 1.4Å resolution. The high thermostability and nanomolar affinity of designed binder makes it a promising candidate for future therapeutics and diagnosis.

Brain Tumor Classification from MRI Using a Hybrid ResNet50–Transformer Architecture with CBAM Attention

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Objectives and background details: Early and accurate brain tumor categorization from MRI is essential for timely treatment planning and better survival outcomes. Although deep learning has improved automated diagnosis, many models still miss subtle spatial cues or fail to learn long-range relationships across the brain region. This work aims to develop a robust hybrid model that improves clinically meaningful feature extraction and dependable tumor classification.

Materials, methods or experiment: MRI scans were categorized into four classes—Pituitary, Glioma, Meningioma, and No Tumor—after standardized preprocessing including resizing, normalization, and augmentation to strengthen generalization. The proposed framework combines a ResNet50 CNN backbone for local feature learning, a Transformer block for capturing global dependencies, and CBAM attention to adaptively emphasize relevant spatial and channel features. Model performance was evaluated using accuracy, precision, recall, F1-score, and AUC-ROC.

Highlighting the observations, finding, discussion and importance: The proposed ResNet50–Transformer–CBAM architecture achieved 96% overall classification accuracy with 98.16% training accuracy and 96.86% validation accuracy, outperforming baseline CNN models and other contemporary deep learning approaches for brain tumor assessment. The ROC performance remained consistently strong, with AUC values above 97% across extended epochs, indicating stable and reliable discrimination. These findings demonstrate that combining local CNN representations with Transformer-based global context and attention-driven feature refinement enhances diagnostic robustness. The model shows strong potential as a decision-support tool to assist radiologists in faster, more accurate, and scalable brain tumor screening, supporting improved clinical workflow and patient care.

Comparative Analysis of DNA Extraction Techniques and PCR Optimization with SSR Markers in *Haldina Cordifolia* (Roxb.) Ridsdale: A First Report

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Haldina cordifolia (Roxb.) Ridsdale (Haldu), a medicinally significant and near-threatened tree native to Central India, belongs to the Rubiaceae family. Despite its ecological and pharmaceutical importance, molecular studies on this species, particularly using microsatellite or simple sequence repeat (SSR) markers, are scarce. Efficient molecular research depends heavily on the quality and purity of extracted genomic DNA, which is particularly challenging in forest species like Haldu due to high concentrations of secondary metabolites, polyphenols, and polysaccharides. This study compared five DNA extraction protocols, optimized and modified Doyle and Doyle (1987), Tamta et al. (2015), Khanuja et al. (1999), Deshmukh et al. (2007), and a charcoal-based method by Krizman et al. (2006), for their effectiveness in isolating high-quality genomic DNA from fresh leaves of *H. cordifolia*.

Among these, the optimized and modified Doyle and Doyle (1987) method produced the best results, yielding DNA concentrations between 524.7 and 857.2 ng/ μ L with an A260/A280 ratio of around 1.8, indicating high purity. Given the lack of species-specific molecular markers, this study also explored the development of SSR markers using bioinformatics tools from the NCBI database. Several markers were successfully amplified in *H. cordifolia*, demonstrating their utility for genetic diversity analysis. To the best of our knowledge, this is the first report to provide not only a reliable, high-throughput protocol for DNA extraction and PCR amplification in Haldu but also to lay the groundwork for future conservation genetics and breeding efforts using SSR markers.

Integrated Docking and Cell-Based Studies of Potential Inhibitors of α -SMA, COL1A1, and TGF- β in the Context of Liver Fibrosis

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Liver fibrosis is a leading cause of liver-related mortality worldwide due to the limited effectiveness of current treatments, remains a significant therapeutic challenge. In order to find and describe strong natural inhibitors that target three important fibrogenic mediators, transforming growth factor- β (TGF- β), collagen type I alpha 1 (COL1A1), and α -smooth muscle actin (α -SMA), this study combines structure-based virtual screening with cell-based validation. The Protein Data Bank provided high-resolution 2D and 3D structures of these targets. Using AutoDock Vina for molecular docking, it was discovered that silymarin and aurantiamide acetate have strong multi-target binding affinities, especially against TGF- β , indicating a potential for synergistic antifibrotic effects. *In vitro* tests, such as MTT and Trypan Blue viability assays, which showed notable cytoprotective effects of specific compounds on HepG2 cells, validated these computational predictions. Furthermore, the downregulation of profibrotic gene expression was validated by RT-PCR analysis, which showed that important fibrogenic pathways were modulated. Interestingly, substances like quercetin, benzyl isothiocyanate, and aurantiamide acetate showed mechanistic activity that was on par with silymarin, the reference standard. This combined *in vitro* and *in silico* method identifies new plant-derived lead molecules for upcoming antifibrotic medication development and highlights a promising therapeutic approach.

Formulation and evaluation of Miconazole loaded Emulgel

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Fungal infections pose a significant public health risk, ranging from superficial skin conditions like *Tinea pedis* to life-threatening systemic mycoses in immunocompromised individuals. While various antifungal agents exist, their effectiveness is often hindered by poor water solubility and low skin permeability. Conventional topical formulations such as ointments and creams frequently suffer from limitations like stickiness, low spreading coefficients, and poor patient compliance. Objective: This study aimed to develop and evaluate a Miconazole-loaded emulgel, a topical drug delivery system designed to overcome the limitations of traditional hydrophobic drug delivery. By combining the advantages of both emulsions and gels, the study sought to create a stable, non-greasy, and thixotropic formulation with superior spreadability and dual-control drug release properties.

Five batches (F1–F5) were formulated using a high-pressure homogenization method. The process involved three primary steps: the preparation of a gel base using Carbopol 934, the creation of an oil-in-water emulsion containing Miconazole dissolved in methanol, and the subsequent incorporation of the emulsion into the gel base. Preformulation studies, including melting point determination, solubility analysis in various solvents, and the establishment of a UV-Vis spectrophotometric calibration curve at the drug's maximum wavelength λ_{max} , were conducted to ensure drug purity and measurement accuracy.

The prepared emulgels were evaluated for physical appearance, pH (adjusted to 5–6.5 for skin compatibility), viscosity, spreadability, and drug content. The study observed that the emulgel system effectively stabilized the hydrophobic drug, Miconazole, within its polymeric three-dimensional structure. Conclusion: The findings suggest that Miconazole-loaded emulgel is a promising topical delivery system. It offers enhanced stability compared to conventional creams and provides a patient-friendly alternative for treating common fungal infections such as candidiasis and ringworm by improving drug penetration through the skin barrier.

Cytotoxic Assessment of Novel 2-(Phenyl)-3H-Benzo[d]Imidazole-5-Carboxylic Acid Derivatives as Anti-leukemic Candidates

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The objective of the study is to synthesize nine hydroxylated 2-(phenyl)-3H-benzo[d]imidazole-5-carboxylic acid derivatives and evaluate their anticancer activity against K562 and Reh leukemia cells. Leukemia remains a major health concern, with drug resistance limiting therapy. Benzimidazole derivatives exhibit broad anticancer activity, and hydroxylation may enhance potency and new treatment options.

All reagents and solvents were used without further purification. CKT1–CKT9 were synthesized by reacting aldehydes with 3,4-diaminobenzoic acid and Na₂S₂O₅ in DMA at 100°C for 6.5–12 h. The products were isolated, purified, and characterized by NMR, MS, IR, elemental analysis, TLC, and melting point determination.

We synthesized nine hydroxylated derivatives of 2-(phenyl)-3H-benzo[d]imidazole-5-carboxylic acids, and evaluated their anticancer activity against K562 and Reh leukemia cell lines. Among them, CKT7 showed notable cytotoxicity, with IC₅₀ values of 32 μM (K562) and 55 μM (Reh), while other derivatives were largely inactive. Live/dead assays demonstrated effective cell death at ≥30 μM. Mechanistic studies indicate that CKT7 disrupts DNA replication, inhibits cell proliferation, and induces G1-phase arrest and apoptosis. These results highlight CKT7's potential as a selective anticancer agent and provide a basis for developing benzimidazole-based therapeutics for leukemia treatment.

Pharmaceutical Sciences

Design, Optimization and *In-Vivo* Evaluation of a Thermosensitive Mucoadhesive *In-Situ* Gel System for Localized Cervical Cancer Treatment

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Cervical cancer remains a leading cause of female mortality worldwide, demanding site-specific drug delivery systems that minimize systemic toxicity. Methotrexate (MTX) is an effective anticancer drug, but its short residence time and limited mucosal retention restrict efficacy. This study aimed to design a localized vaginal formulation to enhance therapeutic performance.

Methotrexate-transferrin (MTX-Tf) conjugate was synthesized via NHS-DCC ester activation and confirmed by NMR analysis. A thermosensitive mucoadhesive *in situ* gel was developed using poloxamer 407 and chitosan, optimized through response surface methodology central composite design. Characterization included physicochemical, rheological, mucoadhesive, *in vitro* release, cytotoxicity, and *in vivo* therapeutic performance evaluations.

The optimized gel exhibited rapid sol gel transition at physiological temperature ($\approx 33.6^\circ\text{C}$), sustained drug release ($\approx 86\%$ over 48 h), and superior *in vitro* cytotoxicity with reduced IC_{50} values. In *In vivo* studies, the cervical cancer was induced in mice via HeLa cell inoculation, and treatment with optimized MTX–Tf gel resulted in significant tumor regression, restoration of cervical histology, and localized drug accumulation. Transferrin conjugation enabled receptor-mediated uptake, while the mucoadhesive matrix ensured prolonged mucosal adhesion and controlled MTX diffusion. Mitochondrial disruption, elevated ROS, and nuclear fragmentation confirmed intrinsic apoptotic activation. The optimized formulation maintained vaginal-compatible pH, showed excellent stability, and caused no irritation or inflammation on histopathological evaluation, indicating biocompatibility. The synergistic combination of the ligand-mediated targeting and a sustained release enhanced therapeutic efficacy with minimal systemic exposure. Overall, the transferrin targeted thermosensitive mucoadhesive *in situ* gel represents a safe and effective localized delivery system for the cervical cancer management.

Synthesis and Biological Evaluation of Endoxifen Conjugates with Short Anticancer 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 have undergone *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. Cytotoxic evaluation via Sulforhodamine B (SRB) assay on MCF-7 and MDA-MB-231 cell lines revealed that free peptides lacked inhibitory activity and mildly promoted cell growth. In contrast, the conjugates exhibited dose-dependent cytotoxicity. END-NGR and END-RGD induced 20–70% growth inhibition in MCF-7 cells and showed cytostatic effects in MDA-MB-231 cells. In comparison with adriamycin and endoxifen, the conjugates were less toxic with $LC_{50} > 80 \mu\text{g/mL}$, indicating a good safety profile for possible combinational or chronic treatment regimens.

Integrated Ligand-Based 2D-QSAR Modeling, Molecular Docking and ADME Profiling of Pyrimidine–Thiazolidinone Hybrids as Anti-Malarial Agents

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Malaria remains a major global health concern, primarily due to the emergence of multidrug-resistant strains of *Plasmodium falciparum*. The continued failure of existing therapies necessitates the identification of novel antimalarial scaffolds capable of targeting essential parasite enzymes. Pyrimidine-based compounds are well-established antimalarial pharmacophores, while thiazolidinone moieties offer favourable binding and drug-like properties. The present study aims to integrate ligand-based QSAR modelling with structure-based molecular docking to rationally design and evaluate pyrimidine–thiazolidinone hybrids as potential multitarget antimalarial agents.

A library of 136 rationally designed pyrimidine–thiazolidinone hybrids were docked along with 2D-QSAR model developed from reported twenty-five 2- amino pyrimidine derivatives against wild-type *PfDHFR* inhibitors employing a GA–MLR approach ($R^2 = 0.9597$, $Q^2 = 0.9409$). Molecular descriptors were generated using PaDEL-Descriptor and the model was rigorously validated. QSAR-guided analogues were further screened for in-silico ADME properties, followed by molecular docking studies against *PfDHFR*-TS (3UM5), *PfDHODH* (7KZ4), and *PfLDH* (1LDG) using AutoDock Vina. Protein–ligand interactions were analysed using BIOVIA Discovery Studio.

The integrated QSAR–docking analysis identified several hybrids exhibiting strong binding affinities exceeding those of standard inhibitors, supported by stable hydrogen bonding, π – π stacking, and hydrophobic interactions with key active-site residues. Notably, the 2D-QSAR model was developed based on a 2-amino pyrimidine nucleus, providing a rational framework for substituent optimisation within the hybrid series. Although some compounds showed minor deviations from Lipinski’s criteria, these were primarily associated with molecular weight and lipophilicity and were considered acceptable at the hit-identification stage due to favourable absorption and binding characteristics. Overall, the study highlights pyrimidine–thiazolidinone hybrids as promising antimalarial scaffolds with multitarget binding potential, warranting further experimental validation.

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 emerged as promising platforms for improving therapeutic efficacy and reducing systemic toxicity in cancer treatment. However, their clinical translation is hindered by unpredictable *in vivo* behavior and the rapid development of drug resistance, particularly in triple-negative breast cancer (TNBC). Nanoparticle physicochemical characteristics and tumor microenvironment heterogeneity critically influence delivery efficiency, while molecular crosstalk among oncogenic signaling pathways further contributes to therapeutic failure, necessitating rational, synergistic intervention strategies.

In this study, a curated dataset of 533 nanoparticle formulations was analyzed to establish quantitative relationships between physicochemical properties and *in vivo* delivery efficiency using machine learning models, including Ridge Regression, ElasticNet, Huber Regressor, Gradient Boosting, and Random Forest. Feature engineering, robust cross-validation, and external dataset validation were employed to ensure predictive reliability. Additionally, molecular docking of phytochemicals sourced from the NPACT and NPASS databases was performed against Cyclin D1, Notch receptors (1–4), BRCA, STAT3, EGFR, and c-Met, followed by molecular dynamics simulations of selected ligand–receptor complexes to assess binding stability.

Ridge Regression demonstrated strong predictive performance ($MSE = 1.87$, $R^2 = 0.95$), with ElasticNet and Huber Regressor showing comparable accuracy, while ensemble models achieved robust prediction of 24-hour delivery efficiency. Docking and molecular dynamics analyses revealed phytochemicals with stable multitarget interactions capable of modulating resistance-associated signaling pathways. Preformulation studies and preliminary development of surface-modified erlotinib–fisetin–loaded lipid–polymer hybrid nanoparticles confirmed formulation feasibility, supporting ongoing optimization. Overall, this integrated machine learning and molecular simulation framework provides mechanistic insights for rational nanocarrier design and highlights phytochemical synergy as a promising strategy to overcome TNBC resistance.

Synthesis and Anticancer Evaluation of Novel 2-((2-chloroquinolin-3-yl)methylene)-3,4-dihydronaphthalen-1(2H)-ones against Breast Cancer Cells

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Quinoline–chalcone hybrids were synthesized to address the limitations of current anticancer therapies. A series of six derivatives (JK22-01–JK22-06) was structurally characterized and evaluated against breast cancer cell lines. Compounds JK22-01 and JK22-02 exhibited strong cytotoxicity against the triple-negative MDA-MB-231 cell line, highlighting their potential as promising lead anti-breast cancer agents.

All reagents were of analytical grade. Compounds were characterized by ¹H NMR, LC-MS/MS, FT-IR, elemental analysis, and melting point determination. Acetanilides were converted to 2-chloro-3-formyl quinolines via POCl₃–DMF, then condensed with acetophenones under basic conditions in methanol, followed by recrystallization from EtOH–H₂O.

The present study highlights the potential of quinoline–chalcone hybridization as an effective strategy for developing anticancer agents capable of addressing drug-sensitive and drug-resistant breast cancers. A series of 2-((2-chloroquinolin-3-yl)methylene)-3,4-dihydronaphthalen-1(2H)-one derivatives (JK22-01 to JK22-06) was successfully synthesized and structurally characterized using ¹H NMR and mass spectrometry, revealing clear variations in substitution patterns among the compounds. Spectral similarities between JK22-01 and JK22-02 suggested closely related structures, while distinct shifts observed for JK22-03 to JK22-06 indicated additional functional modifications. Cytotoxicity evaluation demonstrated that triple-negative MDA-MB-231 breast cancer cells were more sensitive to these derivatives, with JK22-01 and JK22-02 showing the highest potency (IC₅₀ = 5.76 and 8.17 μM, respectively). These findings underscore the importance of this scaffold as a promising lead for further mechanistic investigation and optimization toward effective anti-breast cancer therapeutics.

Synthesis, Characterization, and Biological Evaluation of Kojic Acid Derivatives: In Vitro and In Silico Studies

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Kojic acid (KA), a natural compound with notable biological properties, serves as a versatile scaffold for the development of novel therapeutic agents. This study aimed to synthesize KA-based derivatives and evaluate their multifunctionality. These derivatives hold potential to advance anticancer, antimalarial, antibacterial, and antileishmanial therapeutics, manage oxidative stress, and address the pressing need for multifunctional compounds in modern medicine.

KA derivatives were synthesized via one-pot multi-step chemical reactions and structurally confirmed using advanced spectroscopic techniques, including FTIR, NMR, and HRMS. Its anticancer potential was evaluated in vitro using the MTT assay against human cancer cell lines: HCT-116, PANC-1, MDA-MB-231, and MCF-7. The antimalarial activity was tested against *Plasmodium falciparum* 3D7 using the SYBR Green I fluorescence assay. Antioxidant activity was assessed using the DPPH and ABTS assays to determine radical scavenging properties. Tyrosinase inhibition activity performed in silico using Autodock Vina against the mushroom tyrosinase enzyme (PDB: 2Y9X).

All the derivatives showed low cytotoxicity on cell lines. Their antimalarial activity against *P. falciparum* 3D7 was minimal, with DR-03 exhibiting an IC_{50} value of 54.71 ± 7.65 $\mu\text{g/mL}$, and none of the compounds demonstrated antibacterial or antileishmanial activity. Promisingly, the derivatives showed appreciable antioxidant activity in both DPPH and ABTS assays, with IC_{50} values ranging from 31.82 to 190.90 $\mu\text{g/mL}$, comparable to those of standard antioxidants such as AA and KA. In addition, molecular docking studies of tyrosinase inhibition revealed favorable binding affinities ranging from -8.1 to -7.1 kcal/mol, with the compounds interacting within the active site near the catalytic copper ions, suggesting effective tyrosinase inhibition. Overall, these combined biological and in silico findings highlight the multifunctional nature and indicate that further structural optimization could enhance their potency and selectivity, supporting their potential as promising therapeutic candidates.

Development and Evaluation of Crocetin-Loaded Nanogel from *Nyctanthes arbortristis* for Targeted Topical Therapy of Melanoma

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Skin cancer are one of the biggest concerns for the global healthcare market, since classical medication for such conditions does not solubilize well, is very toxic, and does not target the specific site effectively. Topical drug delivery systems have now been recognized as an innovative approach that allows for site-specific targeting, which results in fewer adverse reactions. However, the purpose of this study was to design and characterize a new nanogel formulation of crocetin, which would be extracted from the *Nyctanthes arbortristis* Linn. plant, for the treatment of skin cancer.

UV-Vis spectroscopy, FT-IR, NMR, LC-MS, and HPLC methods were used to separate crocetin from the seeds of *N. arbortristis* and characterize its structure. Ionic gelation with tripolyphosphate as a crosslinking agent was used to create a chitosan-based nanoparticle system, which was then incorporated into a nanogel formulation. Particle size, entrapment effectiveness, zeta potential, and rheological characteristics were all optimized in the formulation. Molecular docking studies were carried out to assess interactions with cancer-associated proteins, and *in vitro* antioxidant and cytotoxic assays were carried out against melanoma cell lines. Using an animal model of DMBA-induced skin cancer, *ex-vivo* skin penetration and *in-vivo* efficacy studies were conducted to evaluate the effectiveness and safety of the treatment.

In comparison to free crocetin, the optimized nanogel showed better cytotoxic activity, improved skin penetration, and prolonged drug release. Significant tumor shrinkage, improved histopathological characteristics, and low toxicity to critical organs were found in *in vivo* investigations. Modulation of NF- κ B p65 and HDAC1 expressions was confirmed by immunohistochemical analysis, suggesting possible molecular mechanisms of action. These results demonstrate the significance of crocetin-loaded nanogel as a phytochemical-based therapeutic strategy for melanoma treatment that is safe, efficient, and targeted, providing a promising avenue for future clinical applications.

Stimuli-Responsive Co-Loaded Liposomal Drug Delivery System for the Treatment of Breast Cancer

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Breast cancer is a major global health concern with limitations of conventional chemotherapy, including limited specificity, systemic toxicity and side effects. This study aims to design a hypoxia responsive liposomal drug delivery system, loaded with synthesized nitroimidazole derivative, berberine and doxorubicin to achieve targeted drug release in hypoxic tumour microenvironment.

Methods: Liposomal formulations (plain, pegylated and hypoxia responsive) comprising phospholipids, cholesterol and synthesized hypoxia responsive nitroimidazole derivative were developed and optimized by Box-Behnken design. These underwent physicochemical characterization, spectroscopy study (FTIR and ¹H NMR), hypoxia triggered drug release assay, hemolytic toxicity, and cytotoxicity testing against breast cancer cells.

Results: The hypoxia responsive co loaded drug delivery system achieved optimal physicochemical characteristics (~ 200 nm vesicle size, entrapment efficiency of 44% for BER and 73 % for DOX) with minimum hemolysis (~11.5%) and superior cytotoxicity (GI₅₀ 6.5 µg/ml) against MDA-MB-231 breast cancer cells line compared to free drugs and other prepared liposomal formulations. Notably, the synthesised hypoxia-responsive derivative triggered drug release unveiling a significant burst release under induced hypoxic tumour microenvironment, affirming its suitability for desired response exceeding drug release upto 72 hours. These findings offer an advanced approach to deliver drugs within the altered tumour microenvironment, favouring targeted therapy, with enhanced efficacy and reduced systemic side effects. Amid the surge of projecting breast cancer cases worldwide this hypoxia responsive nanoprobe specifically targets breast cancer hypoxic zones inaccessible to conventional therapy, bridging the gap in precision oncology.

Phytochemical Profiling and Experimental Assessment of the Antiuro lithiatic Activity of Aqueous *Momordica charantia* Fruit Extract in an Ethylene Glycol–Induced Urolithiasis Model

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Fruits of *Momordica charantia* Linn. (Family: Cucurbitaceae) have been traditionally used in medicine to treat urinary stones. However, it lacks scientific validation as a nephroprotective agent with antiuro lithiatic properties. The present study estimated the qualitative phytochemical composition and antiuro lithiatic activity of an aqueous extract of *M. charantia* fruits collected from the Sagar region of Madhya Pradesh.

Phytochemical screening was done by established methods to identify major phytochemical constituents. Urolithiasis was induced in rats (Groups II to V) by giving access to 0.75% ethylene glycol in their drinking water for 28 days, except for the normal control group (Group I). This experiment consists of five:

- Group I: Normal control
- Group II: Negative control (hyperuro lithiatic)
- Group III: Standard treatment (Allopurinol, 130 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 antiuro lithiatic agent. Further studies, including clinical trials, are warranted to validate its therapeutic benefits.

Development and Validation of an Environmentally Friendly Analytical Method Using Quality-By-Design Principles With RP-HPLC for Quantifying Metformin Hcl and Sitagliptin Phosphate Monohydrate in Tablet Form: Evaluation of the Method's Environmental Impact

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This study aimed to develop and validate a sustainable RP-HPLC method for the simultaneous quantitative assessment of metformin hydrochloride and sitagliptin phosphate monohydrate, which are prescribed for managing diabetes in conjunction with exercise. This method was developed with consideration for the environmental impact of the reagents and chemicals used, based on the twelve principles of green analytical chemistry.

Methods and materials: An RP-HPLC analysis method was optimized, developed, and validated according to the ICH Q2 (R2) guidelines, utilizing the Analytical Quality-by-Design (AQbD) methodology. At the outset, one factor at a time (OFAT) was employed to identify the variables influencing the responses through trial and error using different mobile-phase compositions and chromatographic conditions. This was followed by the use of a Box-Behnken design (BBD) for further method optimization, employing the Design-Expert[®] software.

Result and Discussions: The analysis utilized a reverse-phase HiQ sil C18HS column (4.6 mm ID × 250 mm L, 5 μm, 100 Å) with a simple mobile phase composed of an isocratic blend of ethanol and 0.025 M ammonium acetate buffer in a 55:45 (v/v) ratio. The solution was pumped at a pH of 4.5, which was adjusted using 1 M orthophosphoric acid at room temperature. The flow rate was maintained at 1.157 mL/min, and detection was performed at a λ_{max} of 256 nm. The optimized HPLC method exhibited outstanding linearity, selectivity, and precision. The sensitivity of the assay was established with a detection limit of 3 ng/mL and a quantitation limit of 10 ng/mL for Metformin HCl. The limit of detection and limit of quantification for sitagliptin phosphate monohydrate were identified as 4 ng/mL and 14 ng/mL, respectively. The method exhibited acceptable precision within a day and over multiple days. The greenness scores of the method were assessed using AGREE, GAPI, Complex GAPI, BAGI, AES, AMVI, and AMGS for the simultaneous estimation of both analytes. This RP-HPLC method is well-suited for routine quality control analysis in the pharmaceutical industry.

Evaluation of *Chlorophytum Comosum* Aqueous Extract against Chronic Alcohol - Induced Cognitive Impairment in Adult Zebrafish

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Chronic alcohol consumption is strongly associated with cognitive impairment and an increased risk of neurodegenerative disorders, such as Alzheimer's disease (AD). The long term ethanol exposure increases the reactive oxygen species, leading to oxidative stress, neuroinflammation, and activation of the kynurenine pathway that promotes the accumulation of neurotoxic metabolites and progressive neurodegeneration. The *Chlorophytum Comosum* is reported to potential antioxidant and anti-inflammatory properties, suggesting its potential to attenuate the ethanol-induced cognitive deficits and AD-like neuropathology. The present study aimed to establish an ethanol-induced cognitive impairment model in adult zebrafish and evaluate the neuroprotective effects of CC extract.

Adult zebrafish (*Danio Rerio*, 3 months old, 470-530 mg) were randomly selected and divided into four groups (n = 12) and acclimatized under controlled conditions (water temperature 26-27°C, pH 6-7 continuous aeration). Cognitive impairment was induced by chronic exposure to escalating ethanol concentrations (0.125-0.625%) via tank water for 26 days. Post treatment with *Chlorophytum Comosum* at the dose of 5 and 10 mg/L via tank water for 14 days, while controls remained in untreated water. Behavioral assessments evaluating locomotion, anxiety-like behavior, learning, and memory were performed at 5-day intervals using the Open Field Test (OFT) and Floating Novel Object Recognition (FNOR) paradigms.

Results demonstrated that the long term exposure of ethanol impaired the locomotor activity, learning, and memory, reflecting the alcohol-induced neurodegenerative and AD-like alterations. The post treatment with *Chlorophytum Comosum* extract dramatically improved exploratory activity and restored the novel object preference, indicating higher cognitive performance. These findings suggested that *Chlorophytum Comosum* extract has neuroprotective and cognition-enhancing benefits, likely through antioxidant, anti-inflammatory, and redox homeostasis-modulating pathways. The work identifies *Chlorophytum Comosum* as a prospective ethnomedicinal option for preventing and controlling alcohol-associated neurodegenerative illnesses, including Alzheimer's disease, warranting further mechanistic and translational investigations.

Advanced Phytochemical Investigation and Structural Elucidation of Flavonoid Compounds from *Prosopis cineraria* Leaves Extract

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Prosopis cineraria, commonly found in arid regions like Rajasthan, is known for its medicinal value due to flavonoid content in its leaves. *Objective:* To isolate and characterize flavonoids, particularly rutin, from the leaves of *Prosopis cineraria*. *Methodology:* Leaves were sequentially extracted using solvents of increasing polarity. Methanolic extract showed the highest yield. TLC and HPLC were used for isolation, and characterization was done via UV, HPLC, and FTIR, comparing with standard rutin. *Results and Discussion:* The methanolic extract yielded 17.6 g of flavonoids. TLC showed an R_f value of 0.62. HPLC gave a retention time of 4.41 min at 272 nm. Spectral data confirmed the isolated compound as rutin reported for the first time from this plant. *Conclusion:* Rutin was successfully isolated and identified from *Prosopis cineraria* leaves, supporting its potential in herbal drug development.

Exploring Formononetin as a Natural Anticataract Agent from In-Vitro Studies

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The polyol pathway is crucial to the pathophysiology of diabetic ocular complications, such as cataracts, which are among the leading causes of blindness. The current study explored Formononetin's preventive properties against diabetogenic cataract formation, with a focus on determining its potential mechanism of action.

The study looks into antioxidant activity, aldose reductase inhibitory, and anticataract effectiveness in pharmacological models. In the ex- vivo study, goat lenses were incubated in Tyrode buffer solution with high concentrations of glucose (55.5 mM) and Formononetin (20, 50, and 100 µg/mL), and was and compared to cataract control lenses.

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Formononetin suppresses the free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) activity in an in vitro study. The in vivo investigation demonstrated that Formononetin prevents lenticular opacity in the glucose-induced paradigm. Formononetin administration significantly value ($p < 0.05$) the antioxidant activity (Catalase (CAT), Superoxide dismutase (SOD), and reduced glutathione GSH) while the enzymes decrease malonaldehyde levels (MDA). Dosing of the sample in Formononetin therapy is considerably valuable ($p < 0.05$), i.e., improved lens protein content.

The findings suggested that Formononetin has prospective anticataract activity by decreasing lens aldose reductase activity and reducing reactive oxidative stress; the formononetin flavanol compounds play a potential role in the treatment of diabetic diseases.

Integrated Transcriptomics and Computational Drug Discovery for Antidiabetic Therapeutic Development

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Type-2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by impaired insulin secretion and persistent hyperglycemia. Despite the availability of multiple therapeutic options, long-term efficacy and adverse effects remain major challenges. Advances in high-throughput transcriptomics and computational drug discovery offer new opportunities to identify disease-relevant molecular pathways and design improved therapeutic candidates. The objective of this study was to integrate bulk RNA-sequencing analysis of human pancreatic tissue with structure- and ligand-based computational approaches to identify and optimize novel small-molecule candidates for antidiabetic therapy.

Bulk RNA-sequencing data from pancreatic tissue samples of 53 living individuals were obtained from a public GEO dataset and subjected to quality control, normalization, differential expression analysis, and functional enrichment. Transcriptomic insights were used to prioritize a disease-relevant molecular pathway for drug discovery. Computational methodologies included protein modeling, molecular docking, three-dimensional quantitative structure–activity relationship (3D-QSAR) modeling, pharmacophore mapping, and virtual screening of designed small molecules. Molecular dynamics simulations were performed to assess interaction stability, followed by in-silico ADMET and drug-likeness evaluation.

The integrative analysis enabled the identification of disease-associated molecular patterns in pancreatic tissue (Genes), providing a rational basis for downstream computational exploration. The in-silico evaluation suggested that the designed small molecules possess favorable interaction potential, structural compatibility, and pharmacokinetic characteristics when assessed relative to reference antidiabetic drugs. Molecular dynamics simulations were employed to examine interaction behavior over time, while ADMET profiling was used to assess drug-likeness and safety-related attributes. Collectively, these findings emphasize the utility of combining transcriptomics-driven insights with computational drug discovery methodologies. The study underscores the potential of this integrative framework as a supportive strategy for guiding antidiabetic drug development and prioritizing candidates for further experimental validation.

Inherently Targetable Hyaluronic Acid-Based Polymeric Nanoparticles for Targeted Delivery of Quercetin in CD44+ Cancer Cells

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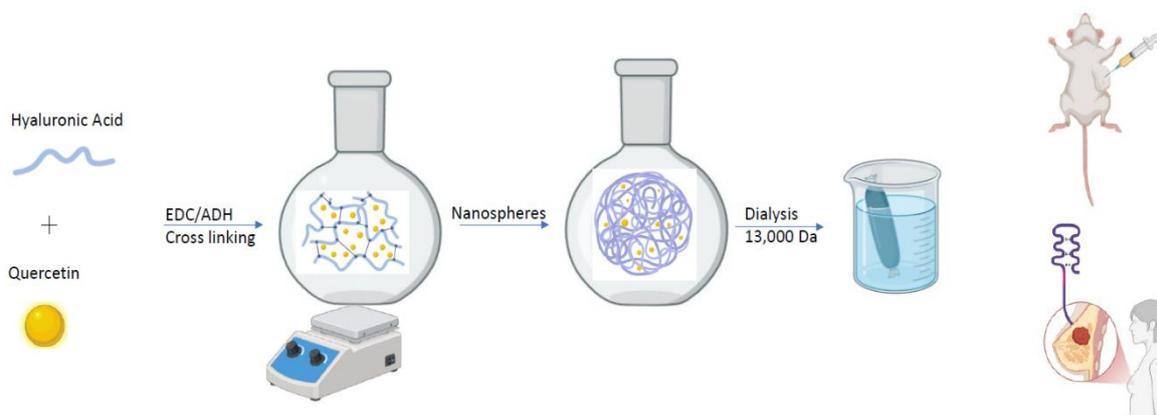
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Cancer is still one of the leading causes of death worldwide, while challenges, like non-targeting and side effects, are still common. Polymeric nanoparticles of a natural biomolecule, hyaluronic acid, can fix these challenges by actively targeting the cell surface transmembrane glycoprotein CD44 to directly deliver quercetin into the cancer cells. Glycolysis and hypoxia-induced acidic tumour microenvironment promote the overexpression of CD44, which is selectively binds with hyaluronic acid. These nanoparticles will be taken up through receptor-mediated endocytosis, where the natural enzyme hyaluronidase and acidic pH will help to break down the polymer to selectively deliver and release the anticancer drug into the cancer cells. This dual strategy will improve the overall treatment outcomes.

In this study, the polymeric nanoparticles of hyaluronic acid were prepared using the nanoprecipitation method and chemical cross-linking by EDC/ADH. The anti-solvent phenomenon causes the collapse and shrinking of hyaluronic acid chains into the globule. This coil-to-globule transition allowed the physical entrapment of the anti-cancer drug quercetin.

After the successful development of nanoparticles, the functional groups were identified using FTIR spectroscopy, confirming the conjugation of HA and ADH. The spherical shape of nanoparticles was confirmed by scanning electron microscopy. The size of blank and drug-loaded nanoparticles was 88.5 nm and 292.3 nm, respectively, zeta potential was -11.7 mV and -15.2 mV, respectively. While entrapment efficacy was found to be 67.24 % with corresponding drug loading percentages of 31.63%, the release percentage in acetate buffer (pH 5.5) after 8 hours was found to be significantly higher than the physiological pH (7.4).



***In silico* Predicts Biomolecular Interaction Anthraquinone Derivatives as PTP1B inhibitor for Anti-Hyperglycaemic Activity**

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Protein Tyrosine Phosphatase 1B (PTP1B) is a key regulator of insulin and leptin signalling and a validated target for obesity-associated type 2 diabetes. This study employed an integrated *in silico* approach to identify potential PTP1B inhibitors. Pharmacophore modelling and molecular docking were used to define key binding features and prioritize promising compounds. Molecular dynamics simulations further evaluated the stability and interaction profiles of the top-ranked PTP1B–ligand complexes. The findings provide computational insights to support the rational design of PTP1B inhibitors for antidiabetic therapy.

PTP1B was selected as the therapeutic target due to its role in insulin and leptin signaling. Anthraquinone derivatives were rationally designed based on structure–activity relationships and key active-site residues. PTP1B (UniProt P18031) was homology modeled using PDB ID 2QBQ, followed by validation and active site prediction using CASTp and PrankWeb. A library of 96 compounds was docked using AutoDock Vina, and the top-ranked complex was further evaluated by 100 ns molecular dynamics simulation and MM-GBSA binding free energy calculations.

Homology modelling using PDB ID 2QBQ generated a reliable 3D structure, supported by favorable Ramachandran, ERRAT, and Verify3D validation scores. Active site prediction using CASTp and PrankWeb identified a dominant binding pocket containing key catalytic residues (Cys215, Arg221, Asp181, Gln262), consistent with reported PTP1B inhibitor-binding regions. Molecular docking of anthraquinone derivatives revealed strong binding affinities, with ANTHK-27 exhibiting the highest docking score (–9.11 kcal/mol) and forming stable hydrogen bond interactions with Cys215 and Arg221, outperforming the reference drug Ertiprotafib. Molecular dynamics simulation (100 ns) demonstrated structural stability of the PTP1B–ANTHK-27 complex, with stable RMSD (~0.25 nm), low RMSF at active site residues, consistent radius of gyration (~2.0 nm), and persistent hydrogen bonding. MM-GBSA analysis further supported these findings, yielding a favorable binding free energy ($\Delta G_{\text{bind}} = -54.72 \pm 2.31$ kcal/mol).

Development and Evaluation of Polyherbal Sunscreen Cream Containing Liquorice, Rice bran oil, Carrot seed oil and Ashwagandha Extract

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This research aims to ascertain the effects of Liquorice and Ashwagandha extract, as well as the combination of Rice bran oil and Carrot seed oil on the efficacy of the sunscreen cream. Ultraviolet (UV) radiation is classified into three wavelength ranges: UV-A, UV-B, and UV-C. Among these, UV-B is responsible for causing sunburn by affecting the epidermal layer of the skin. Ultraviolet radiation has been shown to cause various skin disorders sunburn and related symptoms of prolonged exposure. It has been reported that sunscreens have a beneficial effect in reducing the incidence of skin disorders rays through their ability to absorb the rays and release them from the body in the form of heat. This study aims to formulate a polyherbal sunscreen cream using alcoholic extracts of Liquorice and Ashwagandha, combined with Rice bran and Carrot seed oils, and to evaluate its appearance, homogeneity, PH, organoleptic properties and SPF value determination. Herbal actives are considered safer and more effective than synthetic alternatives. Liquorice abundant in natural antioxidants such as glycyrrhizin (glycyrrhizic acid) and flavonoids, plays an important role in oxidative protection and Ashwagandha is rich in flavonoids and steroidal lactones called withanolides, which have antioxidants properties, and stimulate collagen production. It is reported that carrot seed oil contains an abundant amount of β -carotene and Vitamin C, which act as radical scavenger and assist in skin regeneration. In Rice Bran Oil rich in Vitamin E increases the hydration of skin and chemical like gamma oryzanol suppress the rising melanin levels. Thus, we developed a natural polyherbal sunscreen cream.

A Rapid Delivery Approach with Mouth Dissolving Buccal Films

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Eugenol is the principle chemical constituent of clove oil and has been used to cure dental problems for ages. Eugenol is an essential component of the dentist's kit due to its analgesic, local anaesthetic, antibacterial effects, and anti-inflammatory. It acts as a dental cement, filler, and restorative material in the form of a paste or mixture. This study reports the development and evaluation of mouth dissolving film for oral application. Oral mucosa has rich vasculization and improved permeability to many drugs and it provides an excellent site of drug absorption. Fast dissolving oral film is used as a novel approach, as it dissolves quickly in mouth and directly reaches to the systemic circulation. The aim of this study is to formulate and evaluate the mouth dissolving film of eugenol that would avoid first pass metabolism and give rapid action for, anti-microbial activity in oral cavity. Oral films were prepared by using HPMC 15cps (hydroxypropylmethylcellulose), PEG 400, citric acid and other excipients. The solvent casting method was used to prepare the films. Films were evaluated for mechanical properties, Morphology study, disintegration time, dissolution time and invitro drug release, mucoadhesive strength, antibacterial activity. f3 formulation shows maximum invitro drug release 94.87%, following first order kinetics ($r^2 = 0.9998$).

Design, Molecular Modeling, and Synthesis of Novel Indole–Chalcone Hybrids Targeting *Methicillin-Resistant Staphylococcus aureus*

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Methicillin-Resistant *Staphylococcus Aureus* (MRSA) is a great menace in the world due to its high resistance against a large number of antibiotics and with serious hospital-and community-acquired infections. Increasing antimicrobial resistance leads to the urgent need for some new antibacterial agents having improved efficacy as well as lower toxicity. According to literature reports, indole derivatives show potential antibacterial activities by inhibition of PBP2a. In the current study, in-silico analysis evaluated the hybrid analogs of indole-chalcone for their anti-MRSA activity. The comprehensive in-silico study covered molecular modeling and molecular docking studies and drug design software like 3D-QSAR to design effective antibacterial agents and synthesize the most active molecules.

(2) Result: Based on an in-silico study, new indole-chalcone compounds were planned and checked for their binding strength with PBP2a. The planned molecules showed strong binding with the active-site residues and had better predicted antibacterial activity than the standard molecule. Indole-chalcone derivatives were made using Iodine-helped Michael addition of indole to substituted chalcones under heating in acetonitrile.

(3) Conclusions: Recently conducted computational analysis with indole derivatives using molecular docking and 3D-QSAR has led to a very predictive model for anti-MRSA activity. The high docking scores of the proposed compounds by SCP1, SCP2 and C5P at -7.755 , -7.531 and -7.402 respectively were indicative of their significant inhibitory activity against MRSA target PBP2a. In addition, the most active compounds from these series were prepared by iodine catalyzed Michael addition between variously substituted indoles and chalcones gave some regioselective C-3 substituted indole-chalcone derivatives.

Computer-Aided Design of Benzothiazole-Based Candidates as Potential Anticancer Agents

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Targeted therapy can resolve the major disadvantages of anticancer therapy, like drug resistance and side effects. In order to address resistance, enhance treatment efficacy and safety, and expand treatment alternatives, crucial to develop novel drug candidates for cancer therapy. Synthetic chemists have been interested in benzothiazole and its many derivatives of electron-rich aromatic heterocycles containing endocyclic sulfur and nitrogen atoms because of their special qualities. By providing quick, affordable, and moral substitutes for conventional techniques, in-silico research is revolutionizing the field of drug development, they are beneficial in increases effectiveness of finding novel treatments while lowering the hazards connected with testing on humans and animals.

In the current study, we have chosen a number of compounds from different literature based on their biological activity (IC₅₀) against the cancer cell line MCF-7, prepared their dataset using Chemdraw Ultra 17.0, and carried out in-silico investigations using Sybilx 2.1.1 for 3D-QSAR, Schrodinger Maestro 13.9 for pharmacophore mapping, and SWISS ADME web server for ADME studies.

In the current work, we developed pharmacophore models and 3D-QSAR models that are useful in finding possible drug candidates prior to synthesis, hence saving time and resources in the drug development process. ADME studies are helpful in determining a drug candidate's favourable pharmacokinetic profile. They are also essential in choosing the best drug candidates for the creation of novel drug molecules.

Green Synthesis and Computational Exploration of a Novel Indole-3-Carboxaldehyde Derivatives Targeting Tubulin Protein: DFT Study, Molecular Docking, Molecular Dynamic Simulation and ADMET Evaluation: A Rational Study for the Supportive Treatment for Breast Carcinoma

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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, significant progress has been made in anticancer drug development. The indole nucleus has attracted considerable research interest due to its proven anticancer activity. Notably, Vinca alkaloids, which contain an indole moiety, exhibit potent anticancer properties, highlighting indole as a promising lead scaffold for cancer therapy.

In the present work, a series of novel indole-3-carboxaldehyde derivatives (SKC 1-16) were synthesized employing a sustainable and green synthetic strategy based on ultrasonic irradiation. Structural elucidation and purity of the synthesized compounds were accomplished using advanced spectroscopic techniques. In addition, comprehensive computational studies, including density functional theory (DFT) calculations and in-silico analyses, were carried out to investigate the electronic characteristics and potential biological interactions of the synthesized molecules.

The newly synthesized compounds exhibited superior anti-proliferative activities towards MCF-7 cell line, Molecular docking score -9 to -12 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. In summary, Compound SKC 15 deserved promising consideration for Breast cancer therapy.

Mixed Hydrotropic Solubilization a Novel Technique for Solubility Enhancement of Carvedilol

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The purpose of this study was to prepare and characterize solid dispersion formulation of carvedilol to enhance dissolution rate. Solid dispersions with different drug: carrier ratios were prepared by solvent evaporation method using sodium salicylate, sodium benzoate, citric acid as carrier. The physical state and interactions between the drug and carrier were characterized by infrared spectroscopic (IR), X- ray diffraction (XRD) and SEM. Solid dispersions (especially with drug: Carrier ratio of 1:12) showed a higher dissolution rate than their respective physical mixture and pure carvedilol. The XRD analysis showed that crystalline form was changed to the amorphous state in the solid dispersions. IR analysis did not show any physicochemical interactions in the solid dispersion formulations. SEM photomicrographs obtained for pure carvedilol, 1:4 HSD, 1:8 HSD, 1: 12 HSD From the selected photomicrograph of pure carvedilol, it is clear that the drug was present as irregular shaped crystals. In 1:8 HSD and 1:4 HSD drug particles were absorbed on the carrier particles. While in the photomicrograph of 1:12 HSD, it can be seen that drug particles are absorbed on carrier with decreased particle size and also, the drug particles are entrapped within the carrier matrix. Drug content in physical mixture and solid dispersion was determined. It was observed that grater quantity of drug present in the solid dispersion as compared to its physical mixture. The dissolution properties of carvedilol were improved with the use of hydrophilic carriers in solid dispersions due to change in the crystalline form of the drug and more intimate contact between drug and carriers which was dependent on the type and ratio of concentration.

Design, Optimization, and *In vivo* Evaluation of an Imiquimod-Loaded Niosomal Gel for Targeted Skin Cancer Treatment

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Skin cancer remains a major global health challenge that demands the localized, sustained, and patient-compliant therapeutic approaches. This study aimed to develop a hyaluronic acid-imiquimod (HA-IMQ) conjugated niosomal gel to overcome poor dermal penetration and systemic toxicity through CD44-targeted, controlled topical delivery, thereby improving therapeutic efficacy and overall treatment outcomes.

The HA-IMQ conjugate was synthesized through carbodiimide (EDC/NHS) coupling and confirmed by spectroscopy analysis. Niosomes were optimized using Box-Behnken design, exhibiting uniform vesicle distribution and desirable physicochemical properties, and subsequently incorporated into Carbopol 940 gel. The formulation was evaluated through *in vitro* release, cytotoxicity, cellular uptake, and *in vivo* studies.

The optimized hyaluronic acid-imiquimod (HA-IMQ) conjugated niosomal gel exhibited nanosized vesicles with high entrapment efficiency and a sustained drug release extending up to 72 hours. *In vitro* cytotoxicity studies demonstrated pronounced dose-dependent anticancer activity with a clearly defined IC_{50} value. Cellular uptake studies confirmed efficient receptor-mediated internalization through HA-CD44 interactions, validating the targeting capability of the formulation. Mechanistic evaluation revealed elevated ROS generation, mitochondrial membrane, and activation of apoptotic pathways, collectively indicating potent anticancer efficacy. *In vivo* topical application resulted in significant restoration of epidermal architecture, reduced inflammatory cell infiltration, and reorganization of dermal collagen, reflecting tissue healing and barrier recovery. Furthermore, the formulation achieved drug retention, tumor regression, and minimal systemic toxicity compared to free imiquimod. Overall, the developed HA-IMQ niosomal gel represents a non-invasive, biocompatible, and targeted topical delivery system with excellent therapeutic potential for the localized management of skin cancer.

Design, In-Silico Studies, Synthesis, and Pharmacological Evaluation of Novel Pyrimidine Based Derivatives as Anticancer Agents

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Pyrimidine-based heterocyclic compounds are of considerable interest in anticancer drug discovery due to their ability to interact with key cellular targets involved in DNA replication and cell proliferation. Incorporation of a methylenedioxy moiety is known to enhance biological activity and molecular stability. The present study was undertaken to design and synthesize novel methylenedioxy-substituted pyrimidine derivatives and to evaluate their anticancer potential. Molecular docking studies were performed using AutoDock Vina to investigate interactions with DNA topoisomerase-II, a validated anticancer target. Additionally, *in-silico* pharmacokinetic and toxicity predictions were carried out to identify compounds with favorable drug-like properties and potential for further development.

Chalcone intermediates were synthesized via Claisen-Schmidt condensation of methylenedioxy acetophenone with 3,4,5-trimethoxy benzaldehyde using 70% NaOH in ethanol. These chalcones were subsequently cyclized with urea, thiourea, and guanidine hydrochloride to afford pyrimidine derivatives bearing hydroxy, thio, and amino substituents at the 2-position of the pyrimidine ring. Further structural modification was achieved through alkylation using 1,4-dibromobutane in the presence of 70% NaOH in acetone to obtain bromoalkyl-substituted pyrimidine derivatives. All synthesized compounds were characterized using IR, ^1H NMR, and ^{13}C NMR spectral techniques, and their anticancer activity was evaluated against selected cancer cell lines.

Biological evaluation revealed that thio-substituted pyrimidine derivatives exhibited significantly enhanced anticancer activity compared to their hydroxy and amino counterparts. The incorporation of a brominated alkyl side chain further improved biological efficacy, with increased chain length showing a positive correlation with anticancer activity. In contrast, bioisosteric replacement of thio and hydroxy functionalities with an amino group resulted in diminished activity. Molecular docking studies supported these findings by demonstrating favorable interactions of the most active compounds with the DNA topoisomerase-II active site, while *in-silico* ADMET predictions indicated acceptable pharmacokinetic and toxicity profiles. Overall, these results highlight methylenedioxy-substituted pyrimidine derivatives, particularly those bearing thio functionality and bromoalkyl side chains, as promising lead candidates for the development of novel anticancer agents.

Improving the Antidiabetic Potential of Hesperetin using Phytosomal Drug Delivery System

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Background: Diabetes mellitus is a chronic metabolic disease characterised by long-standing hyperglycemia and disturbed carbohydrate, lipid, and protein metabolism caused by defective insulin secretion or insulin resistance. Hesperetin (HP), a flavonoid with potential biological activities, is only restricted in clinical use due to inadequate aqueous solubility, low permeability, and severe first-pass metabolism with low oral bioavailability. To overcome the bioavailability issues, formulating the phytoconstituents in the form of phytosomes is an emerging technique. Thus, hesperetin phytosomes were prepared and will be subjected to pharmacological evaluation as an antidiabetic agent.

Methods: The current research involves the successful loading of hesperetin into the phytosomal entity by the formation of a complex with soya phosphatidylcholine. The drug-phospholipid complex formation was ascertained by the ¹H-NMR spectroscopy. The phytosomes of the complex were prepared using the thin film formation technique. The physical state of the hesperetin phytosomes was studied through the DSC and XRD. The vesicle morphology was studied by electron microscopy, i.e., SEM and TEM. The prepared phytosomes were subjected to antidiabetic screening in albino rats.

Results: Physicochemical studies and preformulation studies of hesperetin were performed for eg, solubility, melting point, and UV spectroscopy. Complex was prepared and evaluated by TLC, DSC, NMR and XRD. The phytosomes formation were confirmed by XRD, SEM and TEM. In streptozotocin-induced diabetic albino rats, the antidiabetic efficacy of HP phytosomes was assessed and compared with that of pure HP. Studies conducted *in vivo* showed that animals treated with HP phytosomes had significantly lower blood glucose levels than those treated with HP alone, suggesting improved pharmacological efficacy. Furthermore, histopathological examinations of pancreatic tissue revealed preservation and restoration of the islets of Langerhans architecture in the phytosome-treated rats, which is indicative of enhanced regenerative and cytoprotective properties.

Design and Evaluation of Hydralazine Hcl Mouth Dissolving Tablet

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Objective and background: Present investigation aims to develop and evaluate mouth dissolving tablets of Hydralazine hydrochloride which is an arteriolar vasodilator and recommended in treatment of hypertensive urgencies. This work prove a great challenge to the clinical needs for fast release and delivery system to improve therapeutic compliance in patients possessing swallowing difficulties, for example elderly and child patients. This dosage form attempts to exhibit faster onset of pharmacological action and to bypass hepatic first pass metabolism by have rapid dissolution in the oral cavity without the use of water.

Methodology: The experimental procedure started with preformulation studies, in which drug-polymer compatibility was studied using FT-IR. In order to counter the native bitter taste of the active pharmaceutical ingredient, a tastemasking strategy was employed based on a resinate complex with Tulsion-335. Formulations were prepared by direct compression and evaluated for different parameters like weight variation, thickness, hardness, friability, wetting time, in-vitro disintegration time, content uniformity, and in-vitro dissolution.

Result and discussion: From the physical and chemical evaluation the FDT2, having 4 mg of Crospovidone was selected as the best formulation, showing better in vitro disintegration time (20.66 sec) and wetting time (18.66 sec). A comparative study in drug release showed that the optimized Mouth Dissolving Tablet formulation was significantly better than the conventional tablet as reference. However, while the conventional reference tablet released only about 35-40% at 5 min, FDT2 showed an brisk overall drug release of 98.25% in the same period. All the developed MDT formulations exhibited first order release kinetics and the rate of drug release was found to be FDT2 > FDT1 > FDT4 > FDT3 > FDT6 > FDT5.

Fluorescence Intensity Ratio Based Cryogenic Thermometry Via Phonon-Coupled Luminescence in Cr³⁺ Doped ZnGa₂O₄ Phosphor

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Cryogenic temperature sensing is crucial for emerging technologies such as quantum devices, space instrumentation, and low-temperature photonics, where conventional contact thermometry is often impractical. Luminescence-based optical thermometry offers a non-contact alternative; however, many existing approaches rely on thermally coupled electronic states, which can be sensitive to defects and structural variations.

In this work, Cr³⁺-doped ZnGa₂O₄ spinel phosphor was synthesized and structurally characterized using powder X-ray diffraction. Temperature-dependent photoluminescence measurements were performed in the 10–300 K range under 442 nm excitation. The evolution of zero-phonon lines and phonon sidebands was analyzed to establish a phonon-assisted fluorescence intensity ratio thermometric protocol.

At low temperatures, the photoluminescence spectra are dominated by sharp R1 and R2 zero-phonon lines corresponding to the ²E → ⁴A₂ transition of Cr³⁺ ions, accompanied by well-resolved Stokes phonon sidebands arising from phonon-assisted radiative relaxation. With increasing temperature, thermally activated anti-Stokes phonon sidebands progressively emerge on the high-energy side of the R-lines, indicating strong electron–phonon coupling in the ZnGa₂O₄ host lattice. Exploiting this phonon population–driven behavior, a fluorescence intensity ratio (FIR) was defined using the anti-Stokes sideband intensity relative to the total emission. The FIR exhibits negligible temperature dependence below ~75 K due to insufficient phonon population, while showing a monotonic and reproducible variation in the 75–300 K range. The FIR–temperature dependence follows Bose–Einstein statistics, enabling reliable temperature reconstruction with a maximum relative sensitivity of 3.3 % K⁻¹ at 75 K and a reconstruction error below 0.5 K. Unlike conventional FIR thermometers based on thermally coupled electronic levels, the present phonon-assisted approach is governed by lattice dynamics, offering a structurally robust and reliable route for non-contact cryogenic thermometry relevant to low-temperature photonic and quantum technologies.

Shape Dependent Structural and Electronic Properties of BP Nanowires

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One-dimensional (1D) nanowires have unique structural, electronic, and transport properties that come from being quantum confined and having fewer dimensions. This makes them good candidates for next-generation nanoelectronic devices. Among various low-dimensional systems, III–V compound nanowires have attracted considerable interest owing to their tunable electronic properties and applicability in device fabrication.

In this research, we aim to systematically examine the impact of geometry on the structural stability, electronic band structure, and transport properties of boron-phosphide nanowires (BPNWs). Utilizing first-principles density functional theory, linear, zigzag, and triangular configurations are analyzed to elucidate geometry-induced transitions in stability and electronic behavior, yielding insights for the design of nanoscale electronic materials. We performed the geometry optimization using the generalized gradient approximation (GGA) functional with the Perdew-Burke-Ernzerhof (PBE) parameterization. We used plane wave functions with a cutoff energy of 70 Ry, and we did Brillouin zone integration with a k-point sampling of $1 \times 1 \times 50$.

Depending upon the binding energy analysis, linear BPNWs are the most energetically stable configuration. Zigzag and triangular nanowires are still possible to make, even though they are not as stable. Calculations of electronic structure show that linear BPNWs are semi-metallic because the valence and conduction bands overlap at the Fermi level. On the other hand, zigzag and triangular geometries are metallic because the bands cross the Fermi level. An analysis of the density of states reinforces these conclusions further. The modulation of electronic behavior caused by geometry shows how important structural design is for customizing the properties of nanowires. These results give important information for the smart design of nanoscale electronic and transport devices that use boron and phosphide.

Generation of Femtosecond Pulses without Modelocking

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Ultrashort optical pulses are widely used in applications such as optical communications, nonlinear optics, biomedical imaging, and precision material processing. These pulses are commonly generated in ultrafast fiber lasers using the technique of modelocking based on various saturable absorbers. However, these absorbers have certain limitations including environmental sensitivity, low damage thresholds, and birefringence, which degrades the stability and performance of the fiber laser system. In addition, the repetition rate of such laser system is fixed depending upon the cavity roundtrip time. Therefore, an alternative approach capable of generating ultrashort pulses while overcoming these limitations would be highly advantageous.

In this direction, several efforts have been made to generate ultrashort pulses through amplification and compression of long duration pulses generated by gain switched diode laser (GSDLs). GSDL generates incoherent optical pulses with narrow spectral width which cannot be compressed to femtosecond domain. The incoherent part of the pulse can be avoided using Mamyshev regenerator, which comprises of nonlinear spectral broadening of the pulse followed by offset spectral filtering. After that, pulse undergoes parabolic shaping and is subsequently compressed using grating based pulse compressor.

In this work, we demonstrate the transformation of ~42 ps pulses at 1064 nm with a repetition rate of 5 MHz from a GSDL into femtosecond pulses with a duration of ~625 fs. Initially, the 42 ps pulses are amplified using fiber amplifiers and then propagated through passive fiber to induce nonlinear spectral broadening. Subsequently, a narrow portion of the broadened spectrum is spectrally filtered, which removes the incoherent components of the pulse and reduces the temporal duration to ~10 ps. The filtered pulses are then parabolically shaped during propagation through fiber amplifiers and passive fiber. Finally, the parabolically shaped pulses are compressed using a grating-based pulse compressor. The result highlights an effective alternative route for generating high-quality ultrashort pulses without relying on conventional mode-locking schemes. This scheme could be further extended to generate ultrashort pulses from long duration pulses, such as Q-switched pulses.

Investigation of Spin-Correlated Phases in Quasi-Two-Dimensional Layered Honeycomb Oxides $\text{Na}_2\text{M}_2\text{TeO}_6$ (M: Co, Ni)

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In low-dimensional systems, an increased magnetic frustration provides a fertile ground for realising exotic magnetic ground states influenced by competing magnetic interactions. The correlation between lattice and spin degrees of freedom gives rise to intriguing phenomena in materials, such as magnetoelastic effects, making them useful for spintronics and magnetic sensing applications.

The high-quality single crystals of $\text{Na}_2\text{M}_2\text{TeO}_6$ (M = Co, Ni) were synthesised using the modified flux method. The temperature-dependent magnetisation measurements on the grown single crystals were performed using a vibrating sample magnetometer (VSM) in the range 1.5 to 300 K. The magnetisation curves were recorded under field-cooled warming (FCW) conditions for applied magnetic fields of 0.1 T and 1 T for $\text{Na}_2\text{Co}_2\text{TeO}_6$ (NCTO) and 1 T for $\text{Na}_2\text{Ni}_2\text{TeO}_6$ (NNTO), aligned along the crystallographic axes $H\parallel a$ (in-plane) and $H\parallel c$ (out of plane). Furthermore, the signatures of magnetic and ferroelectric transitions in both samples were obtained from temperature and magnetic field-dependent Raman scattering measurements using the laser excitation source with a wavelength of 532 nm (Nd:YAG).

Here, we observe evidence of magnetoelastic responses in quasi two-dimensional layered honeycomb compounds, NCTO and NNTO, using temperature-dependent Raman scattering. Additionally, we observe the signatures of magnetoelectric coupling in NCTO through magnetic field-dependent Raman measurements which is otherwise absent in NNTO due to its centrosymmetric nature. The occurrence of spin-lattice interactions was evident from the renormalisation of phonon parameters across both long-range zigzag antiferromagnetic and short-range magnetic ordering temperatures in both the honeycomb layered oxide compounds. Further signatures of this interaction were notable across the non-trivial magnetic transitions (Kitaev paramagnetic) at 150 K in NCTO and an incommensurate phase at 50 K in NNTO. The Raman scattering results were corroborated by the magnetisation measurements.

Diffusion-Mediated Processing of FeNi Thin Films for Rare-Earth-Free Permanent Magnets

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The recent rare-earth supply crisis has intensified the quest for manufacturing rare-earth-free permanent magnets based on earth-abundant materials, which are cost-effective, sustainable, and have minimal environmental footprint. In this context, $L1_0$ -ordered FeNi has emerged as a strong candidate due to its excellent magnetic properties, making it highly attractive for scalable and climate-resilient technologies. The laboratory synthesis of this phase is challenging because of extremely sluggish interdiffusion of Fe and Ni below order disorder temperature ~ 600 K. In this study, the diffusion-driven structural and magnetic evolution of FeNi multilayer thin films is systematically investigated by employing Cu as a diffusion-promoting dopant, followed by a nitrogen-mediated ordering route.

Fe/Ni multilayer thin films were fabricated in equiatomic composition using a DC-magnetron sputtering system in pure Ar and N_2 atmospheres. Cu was co-sputtered at a concentration of 5 at. % by tuning the sputtering power of the individual targets. Post-deposition annealing was carried out at different temperatures. The resulting structural, diffusion, and magnetic characteristics were investigated using X-ray diffraction, polarized neutron reflectivity, and SQUID-VSM magnetometry.

The results demonstrate that Cu doping significantly accelerates interdiffusion in pure Fe/Ni multilayer by a factor of 50, leaving the magnetic moment nearly unaffected. Building on these results, nitrogen insertion and topotactic extraction (NITE) is currently explored as a novel approach to tailor diffusion pathways and facilitate atomic ordering. During denitridation, combined analysis of nuclear and magnetic scattering length density profiles indicates a progressive transition from a nonmagnetic nitrogen-rich FeN/NiN multilayer state to a magnetically ordered FeNi phase. Also, the increase in perpendicular coercivity provides strong evidence for the formation of the hard $L1_0$ -FeNi phase. This work establishes an effective low-temperature route for processing $L1_0$ -FeNi phase formation, offering a viable pathway toward rare-earth-free permanent magnet development.

Eutectic Microstructure and its Effect On Electrical and Magnetic Properties of V-Ti-Si Alloy Superconductors

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The V-Ti alloys are potential alternatives to the Nb-Ti alloys for high-field applications. Engineering defects by controlling the microstructure is an effective approach to enhance the critical current density (J_C). In this context, silicon addition is expected to induce eutectic microstructures and secondary phases in the $V_{1-x}Ti_x$ alloys, which may improve current-carrying capacity.

The polycrystalline $V_{0.60-x}Si_xTi_{0.40}$ ($x = 0, 0.05, 0.10, 0.15$) alloy superconductors were prepared by arc-melting. A portion of each ingot was annealed at 650 °C for 24 hours. Structural and microstructural characterization was performed using synchrotron X-ray diffraction, optical microscopy, SEM, and EDAX. Electrical resistivity and magnetization measurements were carried out using PPMS and SQUID-VSM.

Silicon addition generates a eutectic microstructure in the $V_{0.60}Ti_{0.40}$ alloy, consisting of β -V-Ti and Ti_5Si_3 phases. Annealing stabilizes the two-phase microstructure and promotes Ti_5Si_3 phase precipitation within the β -matrix. Such a phase separation is also visible at the nanometer scale. T_c decreases with Si addition and improves after annealing. The J_C enhances significantly with Si addition and improves further after annealing. The annealed $V_{0.55}Si_{0.05}Ti_{0.40}$ alloy exhibits the highest J_C among the present alloys, reaching 1.6×10^9 A/m² in the absence of magnetic field and about 4.3×10^8 A/m² in 5 T field. Notably, the zero-field J_C is enhanced more than 10 times as compared to the as-cast $V_{0.60}Ti_{0.40}$ alloy. Analysis of the field dependence of pinning force density suggests that the large amount of grain/cell boundaries and the boundaries of phases with different superconducting properties are effective in pinning the flux lines. The Ti_5Si_3 phase significantly enhances the J_C in high magnetic fields, provided their sizes remain ≤ 100 nm. Additionally, all annealed $V_{0.60-x}Si_xTi_{0.40}$ alloys exhibit a high-field paramagnetic Meissner effect, arising from inhomogeneous flux pinning and significant flux creep.

Comparative Analytical Study of Electrostatic Scaling in High- κ Gate Dielectric Based Si and MoS₂ Channel MOSFETs

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As metal-oxide-semiconductor field-effect transistors (MOSFETs) shrink toward nanometer dimensions, maintaining electrostatic control while suppressing gate leakage have become more difficult. High- κ gate dielectrics offer an effective solution by enabling physically thicker oxides that improve gate capacitance. Additionally, two-dimensional (2D) channel materials enhance electrostatic integrity due to their atomic-scale thickness. However, there is still a limited understanding of how high- κ dielectrics affect the electrostatic and current characteristics of bulk and 2D channel MOSFETs.

In this study, a comparative analytical long-channel modelling framework is employed to investigate Si- and MoS₂-channel MOSFETs paired with SiO₂, HfO₂, and ZrO₂ gate dielectrics. MoS₂ is considered as a representative two-dimensional semiconductor to show the effects of reduced dimensions on electrostatic scaling. Key device parameters, such as threshold voltage, transfer characteristics, ON-state current, OFF-state current, and ON/OFF current ratio, were analyzed thoroughly to understand the combined effects of dielectric permittivity and channel material.

The analysis indicates that Si-channel MOSFETs have higher ON-state currents due to bulk carrier transport. In contrast, MoS₂-based devices show much better ON/OFF current ratios, particularly when paired with high- κ dielectrics, due to their improved electrostatic control. These results provide physical insight into dielectric-channel interactions and highlight the potential of high- κ /2D material combinations for scalable and low-power nanoelectronic applications. This analytical framework is versatile and can be adapted for other two-dimensional semiconductors by adjusting the material parameters.

Effect of Edge-Modified Zigzag Germanium Selenide Nanoribbon as Interconnect: A DFT-NEGF Study

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Edge modification/passivation is one of the prevalent methods for tuning the electronic and transport properties of nanoribbons. Based on edge passivation, various applications of nanoribbons have been explored in the areas of spintronics, nanoscale metal interconnects, sensors, and transistors, among others. Hence, in the present study, we have primarily focused on investigating the properties of bilateral and unilateral edge H-passivated, F-passivated, and Cl-passivated Zigzag Germanium Selenide Nanoribbons (ZGeSeNRs) for metal interconnect applications.

Theoretically, we have designed the bilateral and unilateral edge ZGeSeNR passivated with H, F, and Cl using the Quantum Atomistic ToolKit, which employs density functional theory (DFT) and the Non-Equilibrium Green's Function (NEGF) method. Firstly, we optimized both edge configurations, and after optimization, we then calculated their structural, electronic, and transport properties.

Further, we observed that the bilateral and unilateral edge passivated (H, F and Cl) configurations are thermodynamically stable based on negative values of binding energy (E_b), and can be experimentally realized using various techniques. The structural properties contribute to the stability of nanoribbons; the more negative the value of binding energy (E_b), the greater their stability. Due to its conducting electronic character, as determined by band structure analysis and density of states (DOS) profile, for bilateral and unilateral 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 (12.91 K Ω), L_K (15.12 nH/ μm), and C_Q (3.64 pF/cm) for the H-ZGeSeNR configuration; hence, this configuration emerges as promising choice for nanoscale metal interconnects.

First Evidence of a Giant Intrinsic Terahertz Phase Shift for 6G and Beyond Communication

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Terahertz (THz)–based communication is expected to become a practical technology. Central to these systems is efficient beam steering, enabled by phase shifters. However, most existing phase-shifting approaches are technologically complex and depend on expensive and elaborate infrastructure, limiting their scalability and widespread adoption.

Within the THz electromagnetic spectrum, we explore a novel class of materials for THz phase shift. To demonstrate this behavior, we perform magneto-THz spectroscopy on the magnetoelastic system $\text{Ba}_3\text{BiX}_2\text{O}_9$ ($X = \text{Ir}, \text{Ru}$), synthesized via the solid-state reaction method.

In this work, we report the first experimental evidence of a giant intrinsic THz phase shift arising from a fundamentally new THz phase-shifting mechanism. Using THz spectroscopy, we observe an unprecedented large phase shift of $\sim 600^\circ$ at ~ 0.9 THz in $\text{Ba}_3\text{BiIr}_2\text{O}_9$ across its magnetoelastic transition near 72 K, accompanied by a figure-of-merit four to five times higher than that of existing free-space phase modulators exceeding 90° . Theoretical analysis corroborates our observations, revealing that spin–phonon coupling plays a pivotal role in renormalizing the dielectric function. We further extend this concept to $\text{Ba}_3\text{BiRu}_2\text{O}_9$, which exhibits a giant phase shift of $\sim 565.96^\circ$ at 0.75 THz and a linear phase–frequency response from 0.10 to 0.75 THz across its magnetoelastic transition at ~ 165 K, nearly twice that of $\text{Ba}_3\text{BiIr}_2\text{O}_9$. Notably, these demonstrated materials enable rare magnetic-field control of THz phase shift. Finally, we propose a proof-of-concept MODEM (modulation–demodulation) architecture for THz communication, highlighting the transformative potential of this mechanism for next-generation THz photonics.

Investigation of Temporal Variations in Ionospheric Parameter M(3000)F2 Across Different Latitudinal Regions During the 24th Solar Cycle.

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This paper presents M(3000)F2 variability during Solar Cycle 24 across different latitudes, highlighting its role as a key indicator of maximum usable frequency in long-distance HF radio transmission.

M(3000)F2 from Darwin, Brisbane, and Casey (via [World Data Centre for Solar-Terrestrial Physics, Chilton ukssdc.ac.uk](http://WorldDataCentreforSolar-TerrestrialPhysics.Chilton.ukssdc.ac.uk)) were statistically analyzed, with variability assessed using mean and standard deviation.

The variation of the M(3000)F2 parameter was examined across seasonal, monthly, yearly, and diurnal timescales at low, mid, and high latitudes. Results show that high latitudes exhibit abrupt monthly changes, with a sharp July peak, while other months remain relatively stable. Diurnal variability is significantly higher and more erratic at high latitudes than at low and mid latitudes, where it is modest and similar. Yearly analysis reveals strong high-latitude peaks after 2016, particularly in 2018, while mid latitudes remain largely stable with only a small rise in 2015. Low latitudes exhibit moderate solar cycle variability, including a dip in 2017. Seasonal patterns highlight equinox maxima at low latitudes due to the ionization anomaly, winter peaks and summer minima at mid latitudes with smoother diurnal behavior, and irregular geomagnetically controlled variations at high latitudes, where winters tend toward elevated values and summers remain low and unstable. Solar radiation, Earth's tilt, geomagnetic disturbances, and solar cycle modulation cause M(3000)F2 variability across diurnal, monthly, annual, and seasonal scales, resulting in consistent low and mid-latitude behavior but irregular high-latitude variations. This study enhances scientific understanding of ionospheric dynamics and offers practical advantages for reliable global communication systems.

Use of Machine Learning for the Measurement of Wire Sag in a Pulsed Wire Set-up

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The performance of free-electron lasers (FELs) and synchrotron radiation sources depends strongly on the uniformity of the magnetic field within the undulator. Accurate characterization of the undulator magnetic field is therefore essential to ensure high-quality, stable photon beam generation. Among the various diagnostic techniques available, the pulsed wire method (PWM) is a well-established and widely used approach for measuring integrated magnetic field errors in undulators. However, one of the major sources of uncertainty in PWM measurements is wire sag.

Wire sag is deformation caused by the weight of the wire under tension, which introduces measurement errors. In this study, wire sag measurements are performed using an enamelled copper wire of 500 μm (25 SWG) diameter in a pulsed wire setup. The measurements are carried out for a fixed wire length of 235 cm while varying the applied tension. The sag data are recorded using a Digital Storage Oscilloscope (DSO), and the experimentally measured sag values are compared with theoretical predictions based on classical wire sag models.

To further improve the accuracy of sag estimation, machine learning (ML) techniques are employed. Two ML models—Random Forest Regressor and Multi-Layer Perceptron (MLP) Regressor—are trained using the experimental data to predict sag values at unmeasured or higher tensions. The results show that the MLP model performs better, significantly reducing the deviation between experimental and theoretical sag values. The integration of ML into the PWM framework enables more reliable sag correction and enhances the accuracy of undulator magnetic field measurements. Overall, this approach improves the reliability of PWM setups for undulator field characterization in modern FEL and synchrotron radiation facilities. Future work will focus on implementing dynamic sag correction during pulsed operation and exploring advanced ML models to further enhance prediction accuracy.

Interpreting Finite-Time Phase-Space Distributions and Time Scales in Strong-Field Pair Production

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Understanding whether particle concepts remain physically meaningful at finite, pre-asymptotic times is a fundamental challenge in strong-field quantum electrodynamics (QED). While asymptotic particle spectra are well defined, the interpretation of time-dependent particle distribution functions is far less clear. This work addresses whether such distributions can encode sensible physical information during the particle formation process, particularly when quantum time scales comparable to the electron Compton time are resolved. Although achieving the ultra-strong field strengths required to probe this regime remains experimentally challenging, rapid progress in high-intensity laser technology is expected to make strong-field QED accessible in controlled laboratory environments. In this context, the unresolved question of *when* a particle is formed, rather than only how many are produced asymptotically, becomes especially significant.

In the present work, we investigate electron–positron pair production from the vacuum in a spatially uniform, time-dependent pulsed electric field of Sauter type,

$$E(t) = E_0 \operatorname{sech}^2(t/\tau), \quad (1)$$

characterized by the peak field strength E_0 and pulse duration τ . The analysis is performed within a fully time-resolved quantum kinetic framework that retains the intrinsic non-Markovian character of quantum evolution and enables us to follow the particle distribution function throughout the entire interaction. Both non-perturbative Schwinger pair production and perturbative multiphoton processes are incorporated within a unified formalism, allowing a consistent description of particle dynamics at finite times beyond purely asymptotic observables.

Our results demonstrate that the particle distribution function corresponds to a physically meaningful particle content even at pre-asymptotic times. At intermediate stages of the evolution, the distribution contains an additional contribution correlated with the particle spectrum that would arise if the external field were suddenly switched off. Although this contribution vanishes asymptotically, its superposition with the physical particle component at finite times generates pronounced quantum interference effects in momentum space. Analytical expressions for the relevant formation time scales are obtained in terms of the pulse duration τ and field strength E_0 . These findings provide new insight into the temporal structure of particle creation in strong electromagnetic fields and establish finite-time particle distribution functions as valuable benchmarks for quantum kinetic approaches in strong-field QED.

Controlling Radiative and Non-Radiative Recombination of Charge Carriers at The Surface and Interface of Semiconductors using High-Density Oxide Layers

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The properties of semiconductor heterostructures, quantum structures, and devices are strongly affected by their surface and interface characteristics. Disruption of atomic periodicity at the surface of semiconductors leads to the formation of unsaturated dangling bonds. These bonds cause surface reconstructions and promote the development of a native oxide layer at surface. These surface modifications create a high density of surface states near the band edges. These surface states hinder the electron/hole transport, significantly affecting both radiative and non-radiative recombination. This interference ultimately reduces the device's efficiency and reliability. Therefore, lowering the surface state density is crucial for achieving optimal performance in semiconductor-based devices.

In this context, high quality oxide layers are integrated onto semiconductor surfaces to hybridize the unsaturated dangling bonds, thereby reducing surface state density and stabilizing surface chemistry. Precisely engineered oxide layers reduce non-radiative recombination losses, enhance radiative efficiency, and improve carrier mobility. The effectiveness of oxide layer depends on its structural quality, includes high atomic density, uniform stoichiometry, low interfacial roughness to form a defect-free oxide-semiconductor interface. These conditions can be achieved using a dual ion beam sputtering (DIBS) system, which precleans native oxides via argon ion plasma and subsequently supplies addition moderate energy oxygen ions during deposition to enhance the quality of the oxide layer.

We present our recent findings on indium phosphide and gallium arsenide semiconductors that incorporate various high-density oxide layers, with dielectric constants ranging from 3.7 to 170. These layers, including SiO₂, ZrO₂, and TiO₂ provide advantages in controlling hybridization due to the different crystal allotropes. These oxide layers were deposited using DIBS, allowing for precise control over the kinetic energy of the adatoms. Subsequently, we used surface photovoltage (SPV) and photoluminescence (PL) spectroscopy to study charge carrier transport and recombination across the surface, interface, and bulk of InP and GaAs structure. The enhanced magnitude of the SPV signal, along with insights into the phase of carrier transport and the emission characteristics of excitons, underscore the importance of the atomically smooth nature of the oxide layer in improving the device performance. These findings are important for advanced semiconductor devices, such as low-threshold micro-LEDs, quantum dot lasers/detectors and semiconductor qubits, where atomic-level native oxides and imperfections can strongly influence charge carrier generation, recombination and transport phenomena.

Variability of the Ionospheric Critical Frequency (foF2) in Relation to Geomagnetic Activity at Low Latitude station Austin.

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The critical frequency of the F2 layer (foF2) is one of the most important parameter that reflects the maximum electron density of the ionosphere. The ionosphere shows significant variations with respect to time of day, latitude, longitude, season, solar activity and geomagnetic activity. At low latitude, foF2 is strongly influenced by solar extreme ultraviolet radiation and geomagnetic activities as a result of the energy input from the sun and the self-existing dynamo in the earth core. The aim of our study is to examine the variability of foF2 with geomagnetic indices (Ap, Kp) to analyse the ionospheric response under varying geomagnetic conditions at station Austin during the year 2020.

The data used in this paper is provided by GIRO (Global Ionospheric Radio Observatory) (uml.edu), and [World Data Centre for Solar-Terrestrial Physics, Chilton \(ukssdc.ac.uk\)](http://WorldDataCentreforSolarTerrestrialPhysics.ukssdc.ac.uk). We have used statistical techniques to analyse the data, such as calculating 3 hourly day to day, monthly and seasonal average values of foF2, Ap, and Kp during the year 2020.

It is clear from results that around 09:00 LT foF2 has peak value and Ap, Kp has dip value. The minimum value of foF2 is around 05:00 LT while Ap and Kp has maximum value around 03:00 LT. The maximum value of foF2 is in March and that of Ap and Kp is in September and December respectively. The maximum value of foF2 is in Summer and minimum in Winter. During Equinox Ap has highest value and lowest in Summer. Kp is highest in Winter and lowest in Equinox. These results enhance our understanding of ionospheric behaviour and its response to geomagnetic indices, which is crucial for improving ionospheric processes and radio communication predictions.

Parametric Instabilities in Semiconducting Quantum Plasma with Effect of Fermi Pressure and Bohm Potential

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In this theoretical study, we investigate non-linearity in semiconductor quantum plasma, which is the cause of parametric interaction between electron plasma wave and acoustic wave fluctuation. The non-linear interaction results in amplitude modulation in acoustic waves. The basic equations are Maxwell's equation, Poisson's equation, continuity equation, zeroth-order and first-order momentum transfer equation and equation of motion of a lattice in a piezoelectric semiconductor.

Quantum correction through Fermi temperature and Bohm potential terms modifies the threshold characteristic and growth rate. The dispersion relation for such parametric instabilities is obtained using the Quantum hydrodynamic model of quantum plasma when subjected to static magnetic field applied in angle θ and an inhomogeneous density to the direction of propagation of pump wave with necessary threshold electric field. The nonlinear dispersion relations are then obtained from the coupled nonlinear equations, which reveal parametric instabilities of an intense linearly polarized electromagnetic wave. The numerical estimations are made for n-InSb.

These results can better explain wave patterns in quantum plasma and may enhance technologies such as semiconductors and plasma devices. We apply Quantum hydrodynamic model to investigate how these waves interact, considering how the magnetic field and inhomogeneous density affect the process. The plasma inhomogeneity amplifies the instability in regions of high-density gradient, and the magnetic field has a limited role in balanced configurations, consistent with classical findings. Future work could explore non-uniform magnetic fields, higher-order nonlinearities, or experimental validation of the quantum effects. The results are relevant for high-frequency signal processing, plasma-based sensors, and semiconductor devices

Spectral Domain Low-Coherence Interferometry for Assessment of Thermal Expansion and Thermo-Refractive Effects on Mirror Substrate Materials

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In ground-based gravitational wave detectors, the thermal expansion coefficient and the temperature change of refractive index of test mass optics plays an important role in the performance and sensitivity of the detector. A spectrally resolved low-coherence interferometric technique has been developed and implemented for the measurement of these parameters for substrate materials being used for LIGO test mass in the near-infrared wavelength range.

The experimental setup comprised of a broadband superluminescent fibre-coupled source. The source output was directed to the sample via a fibre-splitter. Light reflected from the top and bottom surfaces of the sample and a reference flat was directed to a spectrometer for simultaneous measurement of optical and geometrical thickness of the sample under test using spectrum of interference fringes. The interferograms were monitored over time while the sample was heated using a pair of resistive heaters.

The phase extracted from the interferogram, after unwrapping, was used to calculate the optical path length delay (OPD). The change in OPD with temperature was used to extract the values of thermal expansion coefficient and thermo-refractive coefficient. The measured values these parameters for fused silica and sapphire were found to be consistent with the values reported in literature. Thus, this setup enabled simultaneous measurement of two independent parameters of the sample with precision down to few ppm. A modified configuration of the LCI set up is also used to measure the angular variation of the test surface down to less than 100 nanoradian, finding application in high precision local surface slope measurement. This will also be used for ringdown measurements of test samples for characterization of coating materials to be used for LIGO test mass.

Unveiling Structural and Magnetic Asymmetry at the Ag/⁵⁷Fe/Ag Interfaces Using XSW-Based Techniques for Spintronics Device Applications

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Magnetic multilayers are central to modern spintronic technologies, including magnetic memory, sensors, and emerging skyrmion-based devices, where information is processed using electron spin. In such systems, magnetic anisotropy, spin-dependent transport, and switching behaviour are strongly governed by buried interfaces. Roughness, intermixing, and structural asymmetry at these interfaces can significantly degrade device performance, leading to reduced stability and switching. The present work addresses this challenge by investigating interface-specific structural and magnetic asymmetry in the magnetic trilayer system.

Sub-nanometer depth resolution was achieved using X-ray standing waves (XSW) generated by an underlying [W/Si]₁₀ multilayer. By varying X-ray incidence angle around the Bragg condition, XSW antinodes were scanned across the trilayer, enabling selective probing of each interface. Depth-resolved structural and magnetic information was obtained by combining X-ray fluorescence (XRF) with isotope-selective grazing-incidence nuclear resonance scattering (GINRS) of ⁵⁷Fe under XSW conditions. Additional characterization was performed using XRR, MOKE, and CEMS. The effect of thermal annealing on interfacial intermixing and magnetic properties was further investigated, complemented by Fe K-edge extended X-ray absorption fine structure measurements to probe local atomic coordination.

The results reveal an asymmetry in interfacial roughness, with the ⁵⁷Fe-on-Ag interface exhibiting a larger root-mean-square roughness ($9.7 \pm 1 \text{ \AA}$) than the comparatively smoother Ag-on-⁵⁷Fe interface ($6.1 \pm 1 \text{ \AA}$). Consistent with this structural asymmetry, GINRS measurements show distinct hyperfine magnetic fields at the two interfaces. The interfacial structure and magnetism remain stable up to 225 °C. However, annealing at 325 °C promotes significant interfacial intermixing, leading to the formation of ⁵⁷Fe nanoparticles within the Ag layers and a transition to a paramagnetic state. This paramagnetic response is attributed to enhanced Fe-Ag coordination resulting from intermixing. These findings establish XSW-assisted XRF and GINRS as powerful interface-specific probes for buried magnetic multilayers and provide critical insights for the design and optimization of spintronic nanostructures.

Controllable Trajectories of Magnetic Micro-Swimmers: Unraveling the Role of Rotational Diffusivity and Geomagnetic Fields

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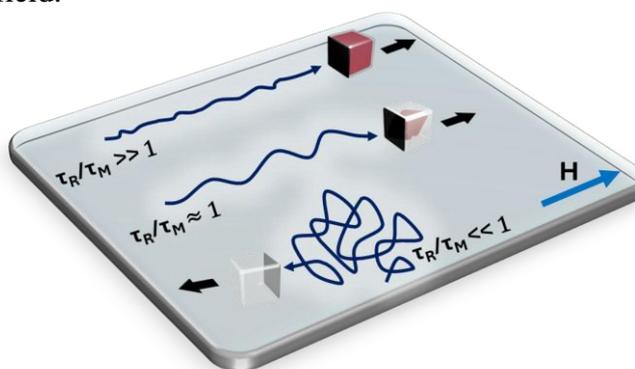
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Understanding the self-propulsion behaviour of active particles and predicting their trajectories is crucial for achieving desired paths by using external stimuli, such as chemical and thermal gradients, electric and magnetic fields, etc. This phenomenon plays a vital role in various fields, such as drug delivery, cargo transportation, and environmental remediation.

In this regard, anisotropic magnetic micro-swimmers (platinum-coated core-shell cube particles) with different intrinsic magnetic strengths have been employed to study the self-propulsion trajectories under a geomagnetic field, using hydrogen peroxide as a fuel medium. Interestingly, these particles exhibit three different types of self-propulsion trajectories based on their intrinsic magnetic strength: random, meandering, and straight tracks, each with a distinct Mean Squared Displacement (MSD).

The experimental and simulation studies revealed that the self-propulsion trajectories are determined by the interplay between rotational diffusivity (D_R) and characteristic magnetic frequency (ω_c) of the particle under the geomagnetic field. Where D_R attempts to randomise the direction of the self-propelled particle, while the ω_c aligns the particles in geomagnetic field direction by constraining the particle angle. This is further confirmed by using another shape of magnetic microswimmer (platinum-coated core-shell spherocylindrical particles), which show similar trajectory behaviour for different ω_c values, confirming that the intrinsic magnetic strength of the particle defines the type of trajectories in the Earth's magnetic field. These distinct trajectories of magnetic active particles were characterised by the ratio of rotational diffusion time ($\tau_R = D_R^{-1}$) and magnetic constraint time ($\tau_M = \omega_c^{-1}$), irrespective of particle shape. Where a particle with $\tau_R/\tau_M \ll 1$ shows a random trajectory, while a particle having $\tau_R/\tau_M \gg 1$ shows a straight trajectory, and for $\tau_R/\tau_M \approx 1$, the particle shows meandering-like trajectories. Finally, we have demonstrated the practical applicability of the core-shell magnetic particles to create complex patterns with controlled fluctuations by using an external magnetic field.



Aggregation Pathways of Proto-Oncogene Protein C-Myb using Markov State Modeling

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C-Myb protein belongs to Myb gene family, which encodes nuclear proteins with tripartite structure. The transcription activation domain (TAD) of c-Myb is disorder under physiological conditions, plays crucial role in cellular regulation, particularly in hematopoiesis. It plays critical role in embryonic development. Loss of function leads to embryonic lethality, primarily due to failure of fetal hepatic hematopoiesis. It has been seen experimentally that TAD of c-Myb forms aggregation.

To understand aggregation process at atomic level, we performed molecular dynamics simulations with multiple copies of TAD region (Residue: 299-312) responsible for aggregation, using ff14IDPSFF force field in Gaussian accelerated molecular dynamics. We applied Markov state modeling to investigate aggregation pathways. With torsional angles as features and properly chosen lag-times, we performed time-independent component analysis and k-means clustering to obtain limited number (~200) of discrete micro-states. Using transition matrix likelihood, we calculated probabilities of transitions between these states. The slowest varying states (~20) were finally obtained by employing Perron-cluster cluster analysis. The major aggregation states comprising of dimers, trimers, tetramers, pentamers, hexamers in nine metastable states were obtained using coarse-graining.

Firstly, to gain insight at atomistic level interactions involved in aggregation, we analyzed contact maps of inter-peptide residue-residue contacts. Three consecutive hydrophobic residue Leucine (Residue: 304-306) are involve in aggregation with high contact probability. From network diagram, we found that most stable state is pentamer with population of ~18.08 %. The association/dissociation rates are calculated for all states. Aggregation pathway with high association rates include: dimer \rightarrow tetramer with association rate $1.5 \mu\text{s}^{-1}$, tetramer to trimer with dissociation rate $1.7 \mu\text{s}^{-1}$, trimer to dimer dissociation rate $2.5 \mu\text{s}^{-1}$, dimer to hexamer association rate $1.4 \mu\text{s}^{-1}$. With help of contact maps and MSM, we map out aggregation pathways of c-Myb.

Interplay of Topology and Electron Correlation in the Surface Electronic Structure of type-II Dirac Semimetal NiTe₂

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Dirac semimetal NiTe₂, hosts a nontrivial band topology motivates its exploration for electronic and spintronic applications. Using angle-resolved photoemission spectroscopy and DFT, we show that bulk electronic structure is well described by mean-field approaches, while an accurate description of the surface electronic structure necessitates the consideration of electronic correlation effects.

Photoemission measurements were performed on in situ cleaved NiTe₂ single crystals at 30 K. DFT calculations were performed in VASP using GGA functional. Surface band structure was calculated using a Te-terminated slab of ten primitive unit cells along with 10 Å vacuum.

We systematically investigate the electronic structure of NiTe₂ using photoemission spectroscopy and band structure calculation within DFT and DFT+*U* method. The experimental Fermi surface can be well captured within the DFT framework. The close proximity of surface state along Γ -M direction to Fermi level distinguishes it from other surface states and suggests a finite contribution of topological surface carriers to the non-trivial transport. Topological surface state formed by the Dirac-like conical crossing at energy -1.42 eV in the ARPES spectra show a discrepancy with DFT results. The electron correlation effects are enhanced while going from bulk to surface and hybridization of the Ni 3*d* and Te 5*p* states results in electron correlation induced shifting of the conical surface state. Our study demonstrates that properly treating the electronic correlation is crucial for accurately determining the topological surface state of NiTe₂. These findings underscore the intricate interplay between electron correlation and band topology, broadening our understanding of many-body correlation effects on the topological surface states in quantum materials.

Earth-Directed Solar Eruptions of November 2025: CME–Flare Coupling, Ground-Level Enhancement, and Extreme Space-Weather Impacts

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Solar Cycle 25's rising phase presents significant space-weather risks driven by explosive magnetic reconnections within the solar atmosphere. This study investigates the 11th November, 2025 solar eruption to elucidate the physical mechanisms of CME–flare coupling and its subsequent terrestrial impacts. The primary objective is to analyze how this integrated framework produces relativistic particle acceleration and extreme geospace disturbances, providing a unique opportunity to study particle transport and magnetospheric response.

This research employs multi-parameter observations from the Royal Observatory of Belgium (Sun Spot Number), NASA OMNIWeb (Interplanetary Parameters), and the Oulu Neutron Monitor (Cosmic Ray Intensity) in Finland. Interplanetary magnetic field (IMF) components, solar wind plasma parameters, and geomagnetic indices (Kp, Dst) were analyzed alongside solar radiative proxies such as sunspot numbers and F10.7 cm radio flux. All datasets were synchronized to a common time base spanning 8 November to 17 November 2025 to facilitate a comparative time-series analysis of the Sun–heliosphere–Earth system.

Observations reveal a severe geomagnetic storm ($Dst \approx -230$ nT; $Kp = 9$) driven by a sustained southward IMF B_z reaching -25 nT and solar wind speeds peaking at 850 km/s. A rare composite cosmic ray response was identified, featuring a prompt Ground Level Enhancement (GLE) like relativistic particle enhancement ($\sim 30\%$) observed at Oulu Neutron Monitor followed by a pronounced Forbush decrease ($\sim 5\%$). These findings highlight the critical role of magnetic connectivity and offer vital insights for future space-weather forecasting and mitigation strategies during the remainder of Solar Cycle 25.

Structural and Luminescent Properties of $\text{Ca}_{1-x}\text{Al}_4\text{O}_7:\text{Eu}_x$ Nanophosphors

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This study investigates the influence of Eu^{3+} concentration ($x = 0.00, 0.01, 0.03, 0.05, 0.07,$ and 0.09) on $\text{Ca}_{1-x}\text{Al}_4\text{O}_7:\text{Eu}_x$ nanophosphors synthesized via a combustion method at 500°C using urea as a fuel. Structural analysis via XRD, morphological characterization with SEM & TEM, elemental composition determination using EDX, and bonding details assessment via FTIR confirm successful nanoparticle synthesis. Photoluminescence (PL) spectra reveal distinct emission peaks at 595 nm and 610 nm attributed to $^5\text{D}_0 \rightarrow ^7\text{F}_1$ and $^5\text{D}_0 \rightarrow ^7\text{F}_2$ transitions of Eu^{3+} ions, respectively. PL intensity shows quenching post CAOE 0.03 ($x = 0.03$). Optimal orange-red emission (0.52, 0.32) with a color temperature of 8655K, Color Rendering Index of 81, and visible watt of 5482154000mW is observed. $\text{Ca}_{1-x}\text{Al}_4\text{O}_7:\text{Eu}_x$ ($x = 0.00$ and 0.03) nanophosphors exhibit potential applications in various fields, while CAOE 0.03 demonstrates eco-material characteristics but lacks antimicrobial activity.

Design and Analysis of Polarization-Insensitive Dual-Band Metamaterial Absorber for Microwave Sensing Applications

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Metamaterials are artificially engineered periodic structures composed of subwavelength elements whose collective behaviour enables controlled manipulation of electromagnetic waves, resulting in unusual physical characteristics. Among the various metamaterial based devices, electromagnetic absorbers are widely studied because of their compact geometry, high absorption efficiency and applicability in sensing, stealth, electromagnetic interference (EMI) mitigation and thermal management.

This work proposes a compact, low profile dual-band metamaterial absorber (MTM-A) for microwave sensing applications. The proposed MTM-A is designed and analyzed using full wave electromagnetic simulations in CST Microwave Studio Suite employing Finite Integration Technique (FIT) over the frequency range of 4-14 GHz. The unit cell consists of a metallic resonator and a continuous metallic ground plane, separated by an FR-4 epoxy substrate with a relative permittivity of 4.3. Geometrical parameters are optimized to achieve dual-band absorption.

Further, the simulation result shows near-unity absorption at 5.57 GHz and 11.09 GHz, with stable performance under variation of polarization angle and oblique incidence under both TE and TM modes. The sensing performance is evaluated using a sample layer whose dielectric constant is varied from 1.8 to 3.6, resulting in a clear frequency shift and a maximum sensitivity of 0.426 GHz/ ϵ . These results confirm the suitability of proposed MTM-A for microwave liquid sensing applications, vegetable oil and petroleum based hydrocarbon liquids.

Chemical Pressure Tuning of Magnetism and Electronic Correlations in $\text{CePdSn}_{1-x}\text{Sb}_x$

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The objective of present work is to study the effect of Sb substitution on magnetic ground state of CePdSn. Considering contrast magnetic ground state of end members (CePdSn is AF with $T_N = 7.5$ K and CePdSb is FM with $T_c = 16$ K), the substitution is expected to result competing magnetic interaction.

Samples were prepared using arc-melting technique. Phase purity and structural parameters were determined through powder X-ray diffraction (XRD) and compositions were determined using EDAX. Magnetic transitions were studied by magnetization, specific heat using relaxation calorimetry and four probe resistivity/magnetoresistance down to 2K and up to 9 Tesla magnetic field.

Powder XRD analysis of $\text{CePdSn}_{1-x}\text{Sb}_x$ ($x = 0 - 0.15$) suggests small amount of $\text{CePd}_{1-x}\text{Sn}_2$ as impurity phase and increase in unit cell volume with x . Both XRD and specific heat indicate Sb substitution up to $x = 0.15$. Temperature dependence of magnetization, specific heat and resistivity shows a decrease of antiferromagnetic transition and Kondo minima with Sb substitution. This can be explained by the weakening of the coupling between conduction electron and f-electron (J_{cf}) due to the negative chemical pressure effect. Temperature dependence of electrical resistivity is well described by crystal electric field (CEF) model using three doubly degenerate levels with excitation energies of 160 and 250 K above the ground state. In contrast, the analysis of magnetic susceptibility and heat-capacity data within a CEF framework yields higher excitation energies of about 200 and 300 K, consistent with reported neutron scattering results. While the CEF level scheme remains robust against Sb substitution, the molecular field parameter becomes positive, reflecting modified exchange interactions. Below T_N , MR and MH data suggests the presence of field-induced transition and positive MR for $x = 0$.

Investigation of Relativistic Electron Beam Generation and Transport in Highly Intense Ultrashort Ti : Sapphire Laser – Solid Interaction

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The advent of terawatt–petawatt laser systems has led to the production of relativistic electrons through intense laser–solid interactions. The transport of these fast electrons provides an efficient channel for energy coupling into dense matter, enabling key applications such as core heating in inertial confinement fusion, ion acceleration and generation of bright ultrashort x-ray source.

Fast electron generation and transport dynamics has been investigated extensively using 150 TW Ti:sapphire laser at RRCAT, Indore. High intensity ($>10^{19}$ W/cm²), ultrashort (25 fs) pulses irradiating solid foils produced relativistic electrons (tens of MeV). Escaping electrons angular distribution from target rear is characterized with DRZ phosphor screen–CCD camera with $\sim 0.1^\circ$ angular resolution. The energy spectrum is measured using magnetic spectrograph (B \approx 750 G) providing $\sim 9\%$ resolution at 10 MeV, covering the range 1.2–40 MeV.

The angular distribution, energy spectrum of fast electron beam is systematically investigated by varying laser intensity and target parameters. At laser intensity of 5×10^{19} W/cm², measured fast electrons' maximum energy (temperature) is ~ 15 MeV (5 MeV), which decreases to ~ 6 MeV (~ 2.5 MeV) with reducing intensity to $\sim 1.5 \times 10^{19}$ W/cm², highlighting strong intensity dependence of electron acceleration. Further, at 5×10^{19} W/cm², the electron beam divergence remains nearly constant ($\sim 40^\circ$ – 45°) for Cu targets with thicknesses from 7 to 50 μm . However, reduction in divergence is observed for higher-resistive targets such as Zr ($\sim 36^\circ$) and Mylar ($\sim 23^\circ$), attributed to resistivity-driven electric field inhibition. Furthermore, non-uniform spatial profiles in thinner metallic and insulating targets indicates pinching effect by self-generated azimuthal magnetic fields. The escaping charge is increased ($\sim 2.6\times$) with Cu target thickness (7–50 μm) and strongly suppressed ($\sim 0.14\times$) in high-resistive target Mylar. Results are relevant in understanding of fast electron transport in ultra-intense laser–matter interactions.

Antibacterial Activity of pure, Green-Synthesized, and Eu-Doped ZnO Nanoparticles

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Zinc Oxide nanoparticles (ZnO NPs) are widely used due to their superior chemical, optical, and antibacterial properties. Doping can improve all the above properties and enhance applicability. This study compares the structural, morphological, and compositional characteristics of pure ZnO (P-ZnO), *Azadiracta indica* (AI) extract-based ZnO (AI ZnO), and Europium-doped ZnO (Eu-ZnO) NPs prepared by a green synthesis method. The samples were further applied for antibacterial activity.

The green synthesis approach is straightforward, easy, economic, eco-friendly, and scalable. The synthesized NPs were analysed and characterized using FTIR (Fourier transform infrared spectroscopy), XRD (X-ray diffraction), UV-Visible spectroscopy, FESEM (field emission scanning electron microscopy), and TEM (transmission electron microscopy) techniques.

XRD analysis confirmed the formation of pure hexagonal wurtzite phase with crystallites of size 17-80 nm. FTIR confirmed the Zn-O bond vibrations. The UV-Visible spectra predicted optical band gaps of 3.3, 3.8, and 2.9 eV corresponding to P-ZnO, AI-ZnO, and Eu-ZnO NPs. Due to health concerns, ZnO NPs were applied for antibacterial analysis against Gram-positive and Gram-negative bacteria, *Bacillus cereus*, *Bacillus subtilis*, and *Escherichia coli*. All the ZnO NPs samples of ZnO NPs exhibited antibacterial activity due to their small size and ability to generate reactive oxygen species (ROS). AI-ZnO NPs were found to be comparatively more effective against all the bacterial species than other samples. The P-ZnO and Eu-ZnO NPs samples were found to be effective against only *Bacillus cereus*.

Beyond Binary Terahertz Modulation for Next-Generation Communication

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The demand for higher data transmission rates is escalating due to a growing user base and rapid technological advancement. Upcoming 6th generation communication technology is anticipated to utilize terahertz radiation, offering access to significantly larger bandwidth. Therefore, developing efficient mechanisms for high-capacity data transmission in the terahertz frequency regime could 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.

Investigating the Structural Phase Transition of $\alpha(2H)$ In_2Se_3 : A Raman Study

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In recent years, the complex characteristics and polymorphic nature (such as α , β , γ , etc.) of indium selenide (In_2Se_3) distinguish it as a prominent candidate among 2D-semiconductors for phase change memory and nano-electronic applications. Among the different polymorphs of In_2Se_3 , α -phase (ferroelectric) is semiconducting in nature whereas β -phase (paraelectric) shows metallic like behaviour. Here, we use temperature-dependent Raman and photoluminescence (PL) spectroscopy to investigate the structural and optical properties of bulk and thin flake of α - In_2Se_3 .

Bulk In_2Se_3 crystals were mechanically exfoliated into thin flakes and then transferred onto the 300 nm SiO_2/Si substrate using a dry-transfer method. The thickness of each flake has been confirmed through atomic force microscopy. Temperature-dependent Raman measurement was carried out on several flakes with different thicknesses, along with a bulk In_2Se_3 starting from 300 K to 500 K. Along with that, low temperature PL measurements give the idea about the optical properties of In_2Se_3 .

Although there are extensive studies on thermal, electrical, and optical properties of In_2Se_3 , the structural dynamics, particularly the temperature-induced phase transitions, remain largely elusive. This work mainly focuses on the less explored polymorph $\alpha(2H)$ of In_2Se_3 , which exhibits a reversible structural transition from α to β -phase with the variation of temperatures. Using temperature-dependent Raman spectroscopy, we systematically investigate both bulk and exfoliated flakes to elucidate phonon evolution and interlayer coupling across this transition. Furthermore, the transition temperature exhibits a pronounced dependence on layer thickness, underscoring the role of reduced dimensionality in governing phase stability and evolution. Moreover, low-temperature PL measurements indicate significant alterations in optical emission, providing insights into carrier dynamics. Our findings refine the understanding of phase transition dynamics in $\alpha(2H)$ In_2Se_3 and provide a deeper foundation for tailoring its phase change and optical properties, essential for integration into future high performance optoelectronic and phase change memory applications.

Lead free PVDF/Ba_{0.85}Ca_{0.15}Zr_{0.1}Ti_{0.9}O₃ Polymer Dielectrics for Energy Storage applications

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In this work, Ba_{0.85}Ca_{0.15}Zr_{0.1}Ti_{0.9}O₃ ceramic was prepared through a low temperature sonochemical method. The polymer composites comprising polyvinylidene fluoride (PVDF)/crystalline BCZT, prepared through the novel cold press method where the wt% of BCZT ceramic filler incorporation into PVDF matrix has been varied systematically to observe its direct effect on energy storage behavior.

The structural, microstructural and dielectric properties of polymer composites have been studied. The formation of the BCZT ceramic was confirmed through X-ray diffraction. The microstructure, homogeneity, and extent of agglomeration of polymer composites were found through the FESEM. The Dielectric properties like dielectric constant, loss tangent, AC conductivity, Z' , Z'' investigated using impedance analyser.

Pure phase tetragonal structure of BCZT with crystallite size of 81nm confirmed using Rietveld refined XRD spectra. Electrical measurements indicate a substantial enhancement in the dielectric constant from PVDF($\epsilon_r=18$) to PVDF/BCZT60% ($\epsilon_r=63$). Moreover, samples with higher filler loading (1-x) PVDF-xBCZT (x=0.5 and 0.6) showed relaxation in low frequencies. The improved dielectric performance of PVDF/BCZT composites as compared to pristine PVDF makes it a promising candidate for high-performance capacitors. The study aimed to enhance the dielectric properties of the flexible polymer dielectrics for advanced electronic applications.

Strain Engineered Magnetic Anisotropy and Relaxation of Obliquely Deposited Thin Films for Flexible and Directional Spintronic Devices

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Controlling magnetic anisotropy and magnetization relaxation at the nanoscale is critical for flexible spintronic devices and strain-tunable microwave absorbers. This work aims to develop a deterministic, composition-preserving route to simultaneously engineer in-plane uniaxial magnetic anisotropy (UMA) and intrinsic Gilbert damping (α) in polycrystalline Co_2FeAl (CFA) thin films by using morphological templating and externally applied strain.

Polycrystalline CFA (~22–25 nm) films were deposited by oblique angle (65° w.r.t. surface normal) electron-beam evaporation on nano-rippled Si (100) substrates. Rippled templates were produced by 500 eV Ar^+ ion erosion (incidence angle $\sim 67^\circ$). To introduce controlled strain, the rippled substrate was mechanically clamped over a curved surface. Surface morphology was analyzed using Atomic Force Microscopy, Grazing-Incidence Small & Wide-Angle X-ray Scattering (GISAXS & GIWAXS), and cross-sectional TEM. Static magnetic properties were measured using the magneto-optical Kerr effect and X-ray magnetic circular dichroism (XMCD). Dynamic properties were studied using frequency-dependent ferromagnetic resonance (FMR) from 2 - 18 GHz.

Ripple templating combined with oblique-angle deposition (OAD) produces tilted columnar growth that deterministically aligns the easy axis along the ripple direction, significantly increasing UMA in the strained state ($H_k \approx 0$ in reference to ≈ 360 Oe in the strained OAD ripple state). FMR reveals an increase in Gilbert damping from $\alpha \approx 0.006$ (reference) to $\alpha \approx 0.018 \pm 0.001$ in the strained OAD ripple film. XMCD and g-factor analysis reveal an orbital unquenching (ml/ms rises from ≈ 0.05 to ≈ 0.12), indicating enhanced spin-orbit coupling (SOC) as the microscopic origin for increased intrinsic damping. This cooperative symmetry-breaking approach, combining ripple geometry, tilted columns, and strain, decouples static anisotropy (shape + magnetoelastic) from dynamic dissipation (surface/strain-induced SOC). The method provides a scalable, composition-preserving route to design strain-tunable absorbers, EMI shields, and conformal spintronic devices compatible with silicon technology.

A High-Sensitivity and Wide-Dynamic-Range Magnetometer Based on An Ensemble of Nitrogen-Vacancy Centers in Diamond

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This work reports the design and realization of a high-sensitivity, wide-dynamic-range magnetometer based on an ensemble of nitrogen-vacancy (NV) centers in diamond. The primary objective is to address the intrinsic trade-off between sensitivity and dynamic range in NV-based magnetometry, which limits applicability in practical sensing environments. By integrating optimized optical detection, active frequency tracking, and magnetic field amplification, the work aims to establish a scalable magnetometer architecture capable of operating under ambient conditions with enhanced robustness and stability.

The magnetometer operates using continuous-wave optically detected magnetic resonance combined with lock-in detection of modulated fluorescence from a high-density NV ensemble in a ^{12}C -enriched diamond. Frequency-modulated microwave excitation is employed to filter out the low frequency noise and maximize the magnetic field responsivity. A balanced photodetection scheme suppresses common-mode laser noise, while a proportional–integral feedback controller implemented on FPGA hardware actively locks the microwave frequency to the NV resonance. Additionally, high-permeability magnetic flux concentrators are integrated to locally amplify the magnetic field, and a dual-resonance magnetometry protocol is implemented to mitigate temperature-induced frequency shifts.

The developed system achieves a magnetic field sensitivity of $279 \text{ pT}/\sqrt{\text{Hz}}$ at 200 mW laser power, which improves to approximately $100 \text{ pT}/\sqrt{\text{Hz}}$ through the combined use of flux concentrators and dual-resonance operation. Active feedback extends the dynamic range from the intrinsic $\sim 3.5 \text{ }\mu\text{T}$ limit to approximately $400 \text{ }\mu\text{T}$ while preserving real-time field tracking. These results demonstrate a significant advancement in NV-ensemble magnetometry by simultaneously achieving high sensitivity, large dynamic range, and thermal robustness, thereby enhancing suitability for applications in biomagnetism, geomagnetic sensing, and precision field measurements.

Effect of Under-layer Induced Charge Carrier Substitution on the Superconductivity of $\text{Ti}_{40}\text{V}_{60}$ Alloy Thin Films

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The superconducting properties of $\text{Ti}_{40}\text{V}_{60}$ alloy thin films are strongly influenced by electronic structure and disorder. In this work, the effect of metallic and semiconducting under-layers on charge carrier substitution and superconductivity is systematically investigated. Films deposited on V, Al, and Si under-layers are compared with a pristine reference film to understand tunability of superconducting parameters and correlation of charge carrier density with superconducting transition temperature (T_C).

Thin films of $\text{Ti}_{40}\text{V}_{60}$ alloy were deposited on different under-layers using magnetron sputtering thin film deposition techniques. Electrical-transport and Hall measurements were performed to probe normal-state conductivity, T_C , carrier type, and carrier concentration. For the estimation of accurate thickness and phase purity of the deposited thin films, X-ray reflectivity (XRR) and grazing angle X-ray diffraction measurements were carried out respectively. Structural disorder and thickness effects were carefully considered, and low-temperature measurements were carried out to ensure accurate determination of superconducting properties.

All films exhibit metallic behaviour in the normal state and a superconducting transition at low temperatures, with the T_C tunable between 4.77 K and 5.73 K depending on the under-layer. XRR analysis shows that all the films are of thickness 25 nm with 10 nm under-layer thickness. Hall measurements reveal that the under-layer significantly alters the charge carrier type and density, establishing a clear correlation between increasing carrier concentration and decreasing T_C . Despite introducing the highest disorder, the Si under-layer yields the highest T_C , indicating that moderate disorder suppresses spin-fluctuation-induced pair breaking inherent to the Ti-V alloy system, thereby enhancing superconductivity. The comparable T_C values of films with V under-layer and without under-layer, along with a coherence length (~ 6.2 nm) much smaller than the film thickness, confirm the absence of proximity effects. These results demonstrate that under-layer engineering is an effective strategy for tuning superconductivity in Ti-V alloy thin films.

High Intensity Laser-Plasma Driven Proton Acceleration, Its Transport and Application

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Laser-driven ion acceleration offers a compact route to generate ions at few tens of MeV energies. When an ultra-short, ultra-intense laser pulse interacts with a thin-foil target, plasma formation and electron heating occur. The fast electrons traverse the target and escape from its rear surface, establishing a strong sheath field (\sim TV/m). Rear-side atoms are ionized and accelerated along the target normal via Target Normal Sheath Acceleration (TNSA). The resulting ion beams, characterized by high peak current and ultra-short duration, are promising for diverse applications.

We report results from proton acceleration experiments conducted at the state of art 1 PW (25 J, 25 fs) Ti:Sapphire laser facility established at Laser Plasma Division, RRCAT, alongside the design and implementation of a proton beam transport system. Experiments were performed at \sim 4 J laser energy, focused to $\sim 10^{19}$ Wcm⁻² on 0.8 μ m aluminium targets. Proton energies and beam profiles were measured using a Thomson Parabola Ion Spectrometer and radiochromic films, while beam charge was quantified with an Integrated Current Transformer.

Protons with energies up to 12 MeV and integrated beam charge of \sim 100 nC were accelerated. To address the intrinsic beam divergence, a pulsed solenoid magnet-based transport system was developed. Two high-field solenoids (3–8 T) focused protons in the 3–6 MeV range, enabling transport over \sim 2.3 m. A focal spot size of \sim 2 mm (FWHM) was achieved. For the first time in India, laser-accelerated protons were applied to irradiate cancer cell lines. Dose-dependent cell death was observed, demonstrating the potential of such beams for radiobiological studies. These results highlight both the feasibility of compact proton sources and their promise for medical applications.

Understanding the Kagome Spin Ice state in a Magnetic Pyrochlore $\text{Dy}_2\text{Ti}_2\text{O}_7$

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Water ice has long been a model for frustration in condensed matter systems because of its well-known proton disorder and macroscopic residual entropy. The local "two-in, two-out" hydrogen bonding rule in water ice has degenerate ground state and has no long range ordering. Since Hydrogen is very difficult to be seen even by X-Rays, it has long been elucidated by models to understand the dynamics of it in water ice. The theories on ice by Bernal and Fowler and a bit later on residual entropy as suggested by L Pauling comes handy in such scenario. However it is after P W Anderson who has predicted to use magnetic pyrochlores along with their spin characters, understanding and more phases of ice has been predicted. In a similar way, rare-earth pyrochlore oxides like $\text{Dy}_2\text{Ti}_2\text{O}_7$ show the same kind of geometrical frustration on their corner-sharing tetrahedral lattice of magnetic Dy^{3+} ions. Spin ice state, which has a ground state degeneracy and magnetic monopole excitations that can be measured very precisely using thermodynamic measurements like heat capacity.

Our research is based on low-temperature thermodynamic characteristics of spin ice behavior in $\text{Dy}_2\text{Ti}_2\text{O}_7$, and our previous work is already done on heat capacity [shruti vyas et al 2025 (12)]. Polycrystalline $\text{Dy}_2\text{Ti}_2\text{O}_7$ samples were produced via a solid-state reaction method with stoichiometric ratio and Dy_2O_3 and TiO_2 precursors used with 1200 C. Using a relaxation calorimetry technique with a Physical Property Measurement System (PPMS) housed in a He3-H4 Dilution refrigerator system at UGC-DAE CSR Indore, we have measured heat capacity from 0.1K to 4 K.

Results include a broad peak seen around 1.2K and its evolution in moderate magnetic fields. We have calculated residual entropy of spin ice in 0T viz is $1.36\text{Jmol}^{-1}\text{K}^{-1}$. Upon fixing the apical spin using moderate fields, the basal adjacent triangular planes started forming the two-in and two-out phase that resembles the degenerate Kagome ice state. Initial results have been reported in Shruti Vyas et al (12).

Identifying Axions in Magnetized Matter f Neutron Star

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Quantum chromodynamics (QCD) axions might solve the mystery of an exact candidate for dark matter (DM). Axions are weakly interacting particles, motivated by the solutions to the strong CP problem physics. The cooling process of neutron stars (NS) occurs through the emission of particles, including neutrinos and axions.

By employing the SLY equation of state (EoS), we solve the modified Tolman-Oppenheimer-Volkoff (TOV) set of equations. We take into account the Bremsstrahlung process that occurs in both the core and crust of the NS. Additionally, we analyze the influence of strong magnetic fields on the luminosity versus the ages of NSs for different masses of axions.

We utilize the maximum permissible limit for the central magnetic field and a radially distance-dependent expression for the magnetic field while generating profiles using the TOV equations. The luminosity of axions produced through the Bremsstrahlung process is significantly higher in the presence of a magnetic field compared to without magnetic field, particularly during the early stages of the NS, within the possible range of axion masses. When a magnetic field is included, we observe a notable difference in the luminosity of axions for all characteristic ages of NSs. Our analysis indicates that the luminosity of particles, such as axions and neutrinos, in the cooling of NSs is largely affected by the presence of an intense magnetic field. With the inclusion of magnetic fields in the EoS and various processes related to the cooling of NSs, we can achieve a better understanding of the underlying physics of the universe. The current results address fundamental questions regarding the formation of stars and galaxies by observing their gravitational effects and electromagnetic radiation.

A Light Regulated Arabidopsis MATE Transporter Promotes Root Hair Elongation Under Low Phosphorus Availability

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The macro nutrient phosphorus is taken up by the plants in the form of Phosphates. Under acidic soil, Phosphates form complexes with cations (Al^{3+} and Fe^{3+}). Plants deploy MATE and ALMT transporters to exude the citrates and malates respectively to competitively bind to the metal ions making the phosphate ions free, which plants can take up from the soil. Genetic manipulations to re-engineer the root system architecture can help the plants improve their phosphate uptake.

We studied *Arabidopsis* root phenotypes under different light conditions, performed qPCR assays to identify the light induced genes, followed by the promoter reporter GUS assays. For transcriptional activation we performed EMSA, dual-glow luciferase and ChiP-qPCR assays. For genetic pathway analysis we generated the double mutants and phenotyped their root system architecture under low phosphate stress.

We identified MATE5 to get transcriptionally induced in the root upon exposure to light. *mate5* mutants exhibit shorter root hairs, indicating their positive role in root hair elongation. Further using EMSA and Chip-qPCR assays we identified a light signaling factor named HY5 transcriptionally activates MATE5 under light. HY5 accumulates under low phosphate stress. HY5 is a positive regulator of root hair development and the genetic analysis identified that MATE5 acts downstream of HY5 to regulate root hair elongation. Additionally, HY5 regulates another auxin responsive transcription factor RSL4 which binds to the RHE elements present in the promoter of MATE5 and upregulates it to enhance the root hair elongation in an auxin dependent manner. Under low phosphate stress both HY5 and RSL4 get induced in the root and enhance the root hair development by upregulating MATE5. Taken together, we identified MATE5 which is regulated by HY5 and RSL4 in response to light and auxin respectively for root hair elongation under low phosphate.

Evolutionary Patterns in the Floral Scents of Gingers: Integrating Field and Laboratory Methods to Reveal the Chemodiversity of Native Plants

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Tropics harbour a huge diversity of plant species with untapped chemical resources that have potential applications in pharmaceutical and perfumery industries. Plants emit volatile metabolites to effectively interact with pollinators, herbivores, or neighbouring plants under varied environmental conditions, while also reflecting genetic constraints, often reflecting species-specific chemical signatures. Among the volatile metabolites, floral scents remain poorly explored in tropical plant groups. The present study investigates the extent and drivers of floral scent variations in the ginger genus *Hedychium*, the only fragrant ginger in the order Zingiberales.

A total of 28 species and five putative hybrids were sampled from multiple wild populations across Northeast India, the Western Ghats, and Northern Thailand over three flowering seasons. Floral scents were non-invasively extracted via dynamic headspace sampling in the field during both day and night and analysed using Gas chromatography-Mass spectrometry (GC-MS) at the parent institution (IISER Bhopal).

Most species occupied distinct chemospaces, indicating species-specific scent signatures. Overall scent blends, individual compounds, and compound classes showed weak phylogenetic signals. Additionally, evening and nocturnal species with pale or white flowers emitted more diel variations, with greater emission at night compared to day-opening species, consistent with pollination syndromes. Putative hybrids exhibited transgressive scent blends, with widely distributed species, showing population-specific variations in total scent and specific class emissions when co-occurring with congeners.

Together, scent variations in *Hedychium* are shaped by ecological features such as distribution and interactions, with limited influence of phylogenetic constraints. Importantly, species-specific uniqueness and the ability to distinguish hybrids highlight the utility of scents in defining taxonomic boundaries, complementing genetic and morphological data for accurate identification. This study also allows us to explore the utility of scent profiles of similar understudied tropical plants in horticulture, perfumery and cosmetic industries.

Investigating the roles of Ethological and Mechanical Isolation in Maintaining Community Structure of a Himalayan Herb

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Biotic interactions are increasingly recognized as key drivers of biodiversity patterns and community structure across ecosystems. In flowering plants, negative interactions can arise among co-occurring species that compete for the same pollinators, yet the mechanisms promoting stable coexistence remain incompletely understood. Two major isolation mechanisms are thought to facilitate coexistence: ethological isolation, mediated by pollinator behavior, and mechanical isolation, mediated by differential pollen placement on pollinators.

To understand this we focused on *Pedicularis* (Orobanchaceae), a highly speciose genus in which many species occur in sympatry, yet natural hybrids are rare, indicating strong reproductive isolation. Here, we test the relative roles of ethological and mechanical isolation by quantifying pollinator constancy and by assessing whether interspecific variation in floral traits influences pollen placement on bumblebee bodies.

Ethological isolation was evaluated by measuring pollinator constancy in natural permanent plots and in experimentally constructed artificial patches containing multiple co-flowering *Pedicularis* species. Mechanical isolation was assessed using two approaches: (1) tracking quantum dot-labeled pollen to determine pollen placement on bumblebee bodies after visits to target species, and (2) directly sampling pollen from different bee body regions following visits without quantum dots.

Pollinators exhibited high constancy in both natural and artificial patches, indicating strong ethological isolation, although constancy was slightly reduced in artificial patches. Floral traits influenced pollen placement precision, with straight-beaked species showing higher precision than curved-beaked species. However, despite differences in peak pollen placement sites, substantial overlap among species was observed, indicating incomplete mechanical isolation.

Together, our results indicate that in *Pedicularis*, ethological isolation through pollinator constancy is the primary reproductive barrier among co-occurring species, while mechanical isolation is present but incomplete. This mosaic of strong behavioral isolation and partial mechanical isolation likely contributes to the maintenance of species boundaries and promotes stable coexistence within diverse plant communities.

Assessment of Panicle Disease and Comparative Metagenomic Analysis of Healthy and Diseased *Paspalum scrobiculatum* L. Reveals Significant Microbial Community Shifts

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Kodo millet (*Paspalum scrobiculatum* L.) is a vital, climate-resilient crop for food security in central India; however, its productivity and safety are increasingly compromised by phytopathogens. The gravity of this issue is highlighted by the 2024 mass mortality of 10 Asiatic elephants in Bandhavgarh Tiger Reserve, linked to the consumption of infected Kodo millet. This study focused on occurrence of panicle disease of Kodo millet along with the identification of its associated fungal pathogens. Additionally, the role of phytobiome during biotic stress has been elucidated in Kodo millet.

The study employed various microbial and molecular methods. Infected plants were identified by visual cues using hand lens followed by collection of infected panicles at booting and maturity stage. Fungal pathogens were identified based on spore morphology and ITS sequencing. Comparative 16S rRNA metagenomic analysis of healthy and diseased plants was conducted to evaluate microbial community shifts associated with the pathogen infection.

This study presents the first identification and isolation of the causal agent of head smut in Kodo millet in Amarkantak region of Madhya Pradesh, identified as *Anthracozygia heteropogonicola* (AMH-10843) through morphological and ITS-rDNA analysis. Prokaryotic community analysis revealed profound microbial dysbiosis; healthy plants exhibited a robust presence of beneficial Actinobacteria, whereas diseased plants were dominated by Proteobacteria and showed a significant loss of microbial diversity. By establishing the pathogen's identity and mapping the microbiome collapse, this research provides a foundation for integrated management strategies to restore crop health, enhance food safety, and prevent future toxicological tragedies affecting humans and wildlife.

Optimization of Solvent Efficiency and Drying Effects on the Antioxidant Activity of *Ocimum tenuiflorum*

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This study was designed to evaluate and optimise the solvent efficiency and drying effect of *Ocimum tenuiflorum* L. (Holy Basil) for enhanced antioxidant recovery. The primary objective was to determine the effects of three practical drying methods (sun, shade, and hot-air oven drying) and two common extraction solvents (methanol and water) on the phytochemical profile and *in vitro* antioxidant capacity of the leaf extracts. The aim was to identify the most effective processing protocol for maximising the yield of bioactive compounds and to understand how different parameters influence specific antioxidant mechanisms, thereby providing a scientific basis for producing standardised, high-potency extracts.

Fresh *O. tenuiflorum* leaves were processed using three independent drying techniques. The resulting dried materials were separately extracted using methanol and water via Soxhlet apparatus. The prepared extracts underwent comprehensive phytochemical screening to identify major classes of secondary metabolites. Quantitative analysis included the determination of total phenolic and total flavonoid contents. The *in vitro* antioxidant potential was assessed through assays: DPPH free radical scavenging, hydrogen peroxide (H₂O₂) scavenging, and reducing power assays. All experiments were conducted in triplicate, and statistical analysis was performed to determine significant differences among the treatment groups.

The investigation revealed that both solvent polarity and drying method significantly modulate the extractable antioxidant profile of *O. tenuiflorum*. Methanol proved superior for the extraction of phenolic and flavonoid compounds, resulting in higher quantitative yields. However, the antioxidant efficacy in specific mechanistic assays was not directly proportional to these yields. Aqueous extracts, despite lower phenolic content, demonstrated remarkably potent activity in certain scavenging assays, indicating the presence of highly active polar antioxidants. The study concludes that methanol is the optimal solvent for extracting antioxidants from *O. tenuiflorum*, highlighting its potential for use in medicine and pharmaceuticals.

Seed Priming with Nano-Biofertilizer Improves Photosynthetic Performance and Antioxidant Response under Drought Stress in Soybean

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Nano-biofertilizers (NBFs), which combine nanoparticles with beneficial microorganisms, have emerged as a promising strategy to improve plant stress tolerance. In this study, we evaluated the potential of nano-biofertilizer consisting of iron oxide nanoparticles (Fe₂O₃ NPs or Fe-NPs) and *B.japonicum* to enhance drought tolerance and physiological performance in soybean (*Glycine max*).

Impact of Fe-NPs on bacterial growth was assessed. Soybean seeds were primed with Fe-NPs and *B.japonicum* for different priming durations to optimise priming conditions, based on germination performance. 10 mg-NBF (10 mgL⁻¹ Fe-NP + *B.japonicum*) with 3 hr priming time was selected and evaluated under irrigated and drought stress conditions for photosynthetic and antioxidant responses.

Further results showed that 10 mg-NBF pre-treatment prevented chlorophyll degradation under drought condition thereby improving overall photosynthetic performance and overall plant growth. Study of Chl a fluorescence induction kinetics showed a drastic increase in various photosynthetic parameters in 10 mg-NBF primed drought stressed plants. NBF priming seems to have protected the photosynthetic apparatus of plant by improving the efficiency of primary photochemistry of PSII under drought stress conditions. Furthermore, the activity of antioxidant enzymes such as catalase (CAT), peroxidase (POD), superoxide dismutase (SOD) and glutathione reductase (GR), as well as malondialdehyde (MDA) content, were decreased significantly in NBF primed drought-stressed plants as compared to unprimed drought stressed plants. These results demonstrate that NBF priming is more effective than individual treatments and represents a sustainable approach for improving drought tolerance in soybean.

Phytochemical Profiling of *Plumbago zeylanica* Roots, Leaves and Stem using Gas Chromatography and UV-Visible and FTIR Spectroscopic Techniques

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Plumbago zeylanica L., commonly known as Chitrak, is a medicinal plant widely used in traditional medicine for its anti-inflammatory, antimicrobial, and anticancer properties. However, detailed phytochemical profiling of its roots, leaves, and stem using complementary analytical techniques remains limited. The present study aimed to investigate and compare the phytochemical composition of *P. zeylanica* roots, leaves, and stem using gas chromatography (GC) and spectroscopic techniques (UV–Visible and Fourier Transform Infrared [FTIR] spectroscopy).

Plant materials were collected, authenticated, shade-dried, and powdered. Sequential extraction was performed using organic solvents of varying polarity to obtain crude extracts. Preliminary qualitative phytochemical screening detected alkaloids, flavonoids, phenolics, terpenoids, and naphthoquinones across all plant parts. GC analysis revealed the presence of plumbagin, β -sitosterol, lupeol, and other terpenoids, with higher concentrations observed in roots compared to leaves and stem. UV–Visible spectroscopy showed absorption maxima corresponding to conjugated aromatic systems, confirming the presence of flavonoid and quinone derivatives. FT-IR spectra provided evidence for hydroxyl, carbonyl, amine, and aromatic functional groups, consistent with GC and UV–Visible observations.

Experimental observations revealed that the roots contained the highest concentration of bioactive phytochemicals, followed by leaves and stem. Comparative analysis demonstrated distinct phytochemical distribution among plant parts: roots exhibited the richest profile with plumbagin and terpenoid abundance, leaves showed higher flavonoid content, and stem contained moderate amounts of phenolics and terpenoids. The combined use of GC, UV–Visible, and FT-IR techniques allowed reliable identification of both volatile and non-volatile bioactive compounds, providing a detailed chemical fingerprint for each plant part.

Ameliorative Effect of *Cinnamomum zeylanicum* on Subacute Toxicity of Oxytetracycline in Albino Rats

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Oxytetracycline (OTC) is a widely used broad-spectrum antibiotic but prolonged use can cause hepatotoxicity due to impaired mitochondrial, peroxisomal and microsomal functions. *Cinnamomum zeylanicum* (Dalchini) possesses antioxidant and anti-inflammatory properties that may protect against drug-induced organ toxicity. The present study aimed to evaluate haematobiochemical and histopathological changes in the liver following sub-acute OTC exposure and to assess the protective effect of *C. zeylanicum* in albino rats.

The present study evaluated the protective potential of *C. zeylanicum* against OTC-induced hepato toxicity in rats. Thirty albino rats were divided into five groups (n=6). Group I, served as control. Group II received OTC (200 mg/kg, orally) for 28 days. Group III received OTC with *C. zeylanicum* extract (200 mg/kg), Group IV received OTC with *C. zeylanicum* extract (400 mg/kg) and Group V received OTC with silymarin (100 mg/kg) for 28 days. On day 28, rats were sacrificed and blood, liver samples were collected for hematological, biochemical, organ weight, gross and histopathological evaluations.

All hematological and biochemical parameters were within normal limits on day 0. On day 28, OTC-treated rats (Group II) showed significant reductions in Hb, PCV, TEC and albumin, along with increased TLC, liver enzymes (ALT, AST, ALP), bilirubin. Mild improvement was observed in Group III, while Group IV showed significant restoration of parameters comparable to control and silymarin groups. Organ weights of liver were significantly increased in Group II, with dose-dependent normalization in *C. zeylanicum*-treated groups. Histopathological examination revealed severe hepatic damage in Group II, whereas Groups IV and V showed marked improvement in tissue architecture. In conclusion, OTC induces significant hepatotoxicity, while *Cinnamomum zeylanicum*, particularly at 400 mg/kg, provides significant hepatoprotection, likely through its antioxidant and anti-inflammatory actions.

Development of an Ai-Based Model for Early Prediction of Canine Anaemia and Clinical Decision Support System

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Canine anaemia is one of the most frequently encountered hematological disorders in small animal practice and is associated with a wide range of infectious, metabolic, renal and systemic diseases. Delayed diagnosis and dependence on clinician experience often lead to late intervention, increasing morbidity and mortality in affected dogs. With recent advances in artificial intelligence, machine learning-based tools have shown promise in enhancing clinical decision-making through data-driven predictions. The present study was undertaken with the objective of developing an artificial intelligence based predictive model for the early identification of canine anaemia and integrating it into a clinical decision support system to assist veterinarians in routine practice.

A comprehensive dataset comprising approximately ten thousand canine cases, including both anaemic and non-anaemic dogs, was generated from clinical and laboratory investigations. Hematological and biochemical parameters routinely used in veterinary diagnostics were curated, pre-processed and subjected to feature selection. Supervised machine learning algorithms were employed for model training and validation, and the best-performing model was optimized for anaemia prediction. The finalized model was integrated into a web-based clinical decision support framework to enable rapid and user-friendly prediction of anaemia risk based on laboratory inputs.

The AI-based model demonstrated promising predictive performance in identifying canine anaemia using routine hematobiochemical parameters. The developed clinical decision support system enabled rapid risk stratification and provided objective support to clinicians, thereby reducing diagnostic delay. The findings highlight the potential of artificial intelligence to complement conventional veterinary diagnostics and improve clinical efficiency. In conclusion, the present work represents a novel and translational application of AI in veterinary hematology, offering a scalable and practical approach for early prediction of canine anaemia and supporting the advancement of precision-based veterinary healthcare.

Pharmacological Evaluation of *Tamarindus indica* Against Sodium Fluoride–Induced Nephrotoxicity in Rats

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Fluoride contamination of groundwater is a serious veterinary and public health problem in Madhya Pradesh, adversely affecting livestock health, productivity, and product quality. Fluoride exposure is known to have deleterious effects on the skeleton, teeth, liver, kidney, and brain due to its ability to induce oxidative stress and initiate lipid peroxidation. The present study aimed to pharmacologically evaluate the nephroprotective potential of *Tamarindus indica*, a widely available medicinal plant, against sodium fluoride (NaF)–induced renal toxicity in rats.

Rats were divided into four groups: Group I received R.O. water; Group II received NaF (100 ppm) in drinking water; Group III received NaF (100 ppm) along with *T. indica* extract (200 mg/kg body weight, orally); and Group IV received NaF (100 ppm) along with ascorbic acid (100 mg/kg body weight, orally) for 56 days. Renal function of rats was assessed through serum and urinary biochemical parameters and antioxidant enzyme activities, along with renal ultrasonography to evaluate structural changes. Moreover, an *in silico* molecular docking study was also performed to explore interactions between major phytochemicals of *T. indica* and renal injury–associated proteins, Keap1 and Kim-1.

Sodium fluoride exposure resulted in significant renal dysfunction, oxidative stress, and ultrasonographic abnormalities. Co-administration of *T. indica* extract markedly improved renal biochemical indices, restored antioxidant status, and normalised renal architecture, outcomes comparable to those of ascorbic acid treatment. Docking studies demonstrated favourable binding of phytochemicals with Keap1 and Kim-1, supporting the observed nephroprotective effects. The study suggests that *Tamarindus indica* possesses pharmacological potential as a natural agent for the management of fluoride-induced renal toxicity.

Studies on Effect of Seasonal Variation on Differential Gene Expression and *In-vitro* Maturation of Caprine Oocytes

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Good quality oocytes are pre-requisite for successful *in vitro* embryo production programmes and crucial step for producing *in vitro* embryo is selection and identification of good quality oocytes which in turn ensures better *in vitro* maturation (IVM). Goats are seasonal breeders, and their reproductive cycles is influenced by environmental and physiological factors. This study is used to analyse the seasonal changes that influences gene expression pattern, oocyte quality, grading and maturation rate in goats.

Oocyte were recovered by slicing technique from slaughter derived caprine ovaries. The recovered oocytes were pooled, graded based on the number of cumulus cell layers, and classified into 4 Grades. Graded oocytes were subjected to IVM which was assessed by cumulus cell (CC) expansion, extrusion of the first polar body (PB-1) and nuclear maturation (NM). After IVM, a subset of oocytes was denuded using 0.25% hyaluronidase. Trizol was used for total RNA isolation. RNA concentration and purity were measured using a Nanodrop Spectrophotometer and were selected for cDNA synthesis. Gene amplification was confirmed by 2% Agarose Gel Electrophoresis. Real-time qPCR using SYBR green master mix qPCR kit evaluated the relative expression of HSP70, GPx, SOD1 and SOD2.

A notably greater number of Grade A and B COCs were recovered during summer and winter compared to the rainy season, whereas Grade C and D COCs were more prevalent during rainy season. HSP 70 expression was highest in summer, followed by winter and rainy seasons. Gpx and SOD 2 transcripts were significantly upregulated in winter, while SOD 1 expression was higher in rainy season. The *in vitro* maturation, cumulus expansion and nuclear maturation were significantly higher in winter. This study concluded that the optimal time of the year for successful *in vitro* embryo production is winter season as more competent oocyte were retrieved in this season.

Molecular Investigation and Pathomorphological Studies on Zoonotic Tuberculosis in Animal-Human Interface: One Health Approach

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The present study aimed to conduct molecular investigation of the *Mycobacterium tuberculosis* complex, *M. tuberculosis* and *M. bovis*, in bovines and assess associated pathomorphological changes. Zoonotic tuberculosis cannot be effectively controlled without addressing disease burden in animal reservoirs and transmission at the animal–human interface, through a One Health approach aligned with the End TB Strategy.

A total of 325 bovines, comprising 169 antemortem and 156 postmortem cases, were screened for tuberculosis. Single intradermal tuberculin testing was performed on 30 bovines. Biological samples, including faecal (n = 58) and tissue samples (n = 10), were collected from clinically suspected and grossly affected animals for molecular detection and pathological evaluation using special stains.

Of the 169 clinically examined bovines, 58 (34.32%) exhibited signs suggestive of tuberculosis, with rough hair coat, pale mucous membranes, and emaciation being the most common findings. Among the tuberculin-tested animals, 12 (40%) were identified as reactors. Ziehl–Neelsen staining of faecal and tissue impression smears demonstrated acid-fast bacilli in 53.44% (31/58) and 50% (5/10) samples, respectively. Molecular detection using IS6110 PCR identified *Mycobacterium tuberculosis complex* (MTC) in 48.38% (15/31) of faecal samples and 100% (5/5) of tissue samples. Species-specific PCR further confirmed *M. bovis* in three tissue samples and *M. tuberculosis* in two. Sequencing and phylogenetic analysis of five PCR-positive isolates corroborated these findings, with four isolates clustering closely with *M. bovis* and one with *M. tuberculosis*. Postmortem examination revealed gross tuberculous lesions, predominantly in the lungs and associated lymph nodes, in 6.41% (10/156) of carcasses. Histopathology revealed granulomas at different stages, including caseous, fibrotic, and mineralized forms, while special stains confirmed acid-fast bacilli and fibrosis. Overall, integrated clinical, molecular, and pathological approaches effectively confirmed bovine tuberculosis molecular, and pathological approaches effectively confirmed bovine tuberculosis under field conditions, highlighting its reverse zoonosis and economic significance.

Seroprevalence, Expression of Immunogenic Fusion Protein and Differentiating Real Time PCR Of Lumpy Skin Disease Virus

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Lumpy skin disease (LSD) is an economically significant vector-borne viral disease of cattle caused by the Lumpy skin disease virus (LSDV), belonging to the genus *Capripoxvirus*. The disease leads to severe production losses and poses a major threat to the livestock industry in India. The present study was undertaken to determine the seroprevalence of LSDV in cattle from Madhya Pradesh, clone and express an immunogenic fusion protein of LSDV, and to detect and differentiate LSDV from other capripox viruses using real-time PCR.

For the sero-epidemiological investigation, a total of 116 cattle serum samples were collected from different districts of Madhya Pradesh during 2022–2024 and screened for LSDV-specific antibodies using an indirect ELISA. Epidemiological data related to breed, age, sex, and immunization status were recorded. Genomic DNA extracted from LSDV-positive tissue samples was used for amplification of a 447 bp fragment of the A27L gene, which was cloned into pJET1.2/blunt and subsequently subcloned into the pQE30 expression vector. Recombinant protein expression was induced in *Escherichia coli* M15 cells and purified using Ni-NTA affinity chromatography. Real-time PCR targeting the RPO30 gene was employed for detection and differentiation of capripox viruses.

The seroprevalence of LSDV in Madhya Pradesh was found to be 31.89% (37/116), indicating active viral circulation. Sex and immunization status showed a significant association with antibody prevalence, while breed and age did not. The recombinant A27L fusion protein was successfully expressed as a ~17.7 kDa protein. Dot blot ELISA performed using field-positive serum samples demonstrated strong reactivity with the recombinant protein, thereby confirming its immunogenic potential. Real-time PCR efficiently detected LSDV and differentiated it from other capripox viruses with high specificity. The study provides valuable epidemiological data, validates a reliable molecular diagnostic approach, and highlights the potential application of the A27L protein in LSD diagnostics and future vaccine development.

Isolation, Identification and Antibioqram Study of *E. coli* Isolated from Bovine Mastitis Milk

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Bovine mastitis is the most common disease in dairy animals. It is the inflammation of the udder, usually caused by various bacterial pathogens, continues to pose a significant challenge to animal health and productivity. Mastitis is considered as a serious problem of dairy animals affecting animal welfare as well as economically leads to huge losses to the dairy industry. The present study was conducted to isolate and identify *E. coli* from bovine mastitis milk in and around Jabalpur.

A total of 210 bovines were screened for mastitis through California Mastitis Test (CMT) and positive samples were inoculated in Brain Heart Infusion broth followed by Nutrient Agar and MacConkey lactose Agar. These samples were further inoculated on to specific culture media for isolation of *E. coli* and further identified by gram staining, biochemical tests/ BD Phoenix M50 automated machine. The antimicrobial sensitivity of isolates was tested by Kirby Bauer disc diffusion method.

A total of 34/210 (16.19%) samples were reported positive for clinical mastitis. Out of this six isolates (17.64%) were confirmed as *E. coli*. They were showing pink colonies on MLA and green metallic sheen on EMB Agar. On Gram's staining they appear as short rods. Genotypic identification using *16S rRNA* revealed that 100% phenotypically confirmed isolates of *E. coli* were found positive. The antibiogram revealed that the isolates of *E. coli* showed resistance against Ampicillin (83.33%) and Cefoxitin (66.66%), while shows sensitivity towards Amikacin (83.33%), Gentamicin (83.33%) and Tetracycline (83.33%). These result highlights the significant concern of antimicrobial resistance in *E. coli* isolates from mastitic milk and emphasize the critical need for prudent antimicrobial use and on-going surveillance to effectively manage mastitis and mitigate the impact of resistance in dairy farming.

Analytical Study On Blood Pressure Measurement In Dogs

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This study investigated the association of blood pressure with various clinical conditions in dogs. A total of 214 dogs (149 males, 65 females) of varying age and breed were surveyed at Veterinary Clinical Complex, C.V.Sc. & A.H., N.D.V.S.U., Jabalpur, Madhya Pradesh, from May, 2024 – October, 2024.

Blood pressure was measured using the Doppler method. Of these, 81 apparently healthy dogs were evaluated for normal systolic arterial pressure (SAP), with a mean SAP of 135.03 ± 1.76 mm Hg. Based on ACVIM classification, 53% had SAP <140 mm Hg (minimum risk), 44.4% had 140–159 mm Hg (mild risk), and 2.46% had 160–179 mm Hg (moderate risk).

Hypertension (SAP ≥ 160 mm Hg) was observed in 18.22% of dogs, with 27.81% being secondary and 2.46% idiopathic. It was more prevalent in males (76.92%) and dogs over 8 years (30%), with Labrador Retrievers showing the highest breed-specific prevalence (6.07%). Blood pressure analysis in 133 diseased dogs revealed significantly higher SAP ($p < 0.01$) compared to healthy dogs. Clinical conditions included renal, cardiac, hepatic, neurological, ocular disorders, obesity, epistaxis and others. Among renal cases, 21.62% had SAP ≥ 160 mm Hg, with 13.79% at high risk, especially in stages 3 and 4 of renal failure. In cardiac conditions, 13.51% showed SAP ≥ 160 mm Hg, with 9.09% at high risk. Epileptic dogs had 16.21% with SAP ≥ 160 mm Hg, including 45.45% at moderate and 9.09% at high risk. Hepatic ascites cases had 8.10% with SAP ≥ 160 mm Hg, mostly at minimal risk. Ocular cases also showed 8.10% prevalence, with 16.67% at high risk. The findings highlight the importance of routine blood pressure monitoring in dogs, particularly those with underlying diseases, due to the strong association of hypertension with various clinical conditions and its potential impact on target organ health.

Season-Dependent Expression of the Mitochondrial-Derived Peptide Humanin in Buck Semen and Reproductive Tissues and Its Association with Semen Quality

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Mitochondrial-derived peptides (MDPs) have emerged as critical regulators of cellular survival, energy metabolism, and oxidative stress. Humanin, the first identified MDP, exhibits potent cytoprotective and anti-apoptotic properties, particularly in tissues with high metabolic demand. Although humanin has been reported in the male reproductive system of several mammalian species, its presence and seasonal regulation in caprine bucks remain unexplored. The present investigation aimed to detect humanin in semen and reproductive tissues of Barbari and Sirohi bucks and to evaluate its seasonal expression in relation to semen quality and oxidative stress indices.

Twelve breeding bucks of Sirohi maintained under uniform management conditions were evaluated over different seasons classified using the temperature–humidity index (THI). Semen samples were assessed for ejaculate volume, sperm concentration, motility, and mitochondrial membrane potential, while oxidative status was determined by measuring lipid peroxidation and superoxide dismutase activity. Immunocytochemistry and immunohistochemistry were employed to localize humanin in ejaculated spermatozoa, testis, and epididymis.

Humanin immunoreactivity was consistently detected in the acrosomal and neck regions of ejaculated spermatozoa, elongated spermatids within seminiferous tubules, interstitial tissue of the testis, and epididymal sperm cells. Notably, the intensity of humanin expression varied with season, showing markedly stronger fluorescence during the rainy season compared with summer and winter. This period also coincided with significantly improved semen characteristics, including higher sperm concentration, motility, and mitochondrial membrane potential, alongside reduced lipid peroxidation. The findings provide the first evidence of seasonal modulation of humanin expression in caprine bucks and suggest a potential role of this peptide in maintaining sperm function under favorable thermal conditions.

Therapeutic Management of Systemic Hypertension in Dogs: A Clinico-biochemical Study

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The present study was undertaken to diagnose systemic hypertension and evaluate the therapeutic efficacy of antihypertensive drugs, with clinico-biochemical insights, in dogs presented to the Veterinary Clinical Complex, College of Veterinary Science and Animal Husbandry, Nanaji Deshmukh Veterinary Science University, Jabalpur, Madhya Pradesh. A total of 2,548 dogs of either sex, irrespective of breed and age, were screened over a six-month period from July to December 2025.

Dogs with suspected systemic hypertension underwent standardized Doppler systolic arterial pressure (SAP) measurement using Doppler Vet BP device (Sono Med MD4, Mano Medical Company) as per standard American College of Veterinary Internal Medicine guidelines. Among these, 251 clinically suspected dogs were evaluated and 65 dogs were confirmed hypertensive, recording an overall occurrence of 25.89 % (65/251).

The therapeutic efficacy of Ramipril (ACE inhibitor) administered at a dose of 0.125 mg/kg body weight orally once daily in combination with Amlodipine (calcium channel blocker) at 0.25 mg/kg body weight orally once daily for 28 days (Group 1) was compared with Telmisartan (angiotensin receptor blocker) administered at 1 mg/kg body weight orally once daily in combination with Amlodipine for the same duration (Group 2). Haematological, biochemical, lipid and electrolyte parameters showed significant improvement following therapy. Both treatment protocols resulted in a progressive and statistically significant reduction in SAP from day 7th onwards in Group 1 and from day 3rd onwards in Group 2 indicating a faster early response with Group 2. Haemato-biochemical, lipid and electrolyte profiles improved towards physiological limits by day 28 (post-treatment) in both groups. The study concludes that telmisartan in combination with amlodipine provides effective, early and sustained control of SAP values. These results suggested hemodynamic assessments is a highly effective strategy for the detection of hypertensive animals, thereby emphasizing the critical necessity of integrating routine blood pressure monitoring into the care of dogs suffering from ailments frequently associated to hypertension.

Comparative Therapeutic Efficacy of Bacteriophage and antibiotics in Staphylococcal Mastitis in Cattle

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Bovine mastitis is a major cause of economic losses in the dairy industry. *Staphylococcus* species are the predominant pathogens and exhibit high antimicrobial resistance, resulting in poor response to conventional antibiotic therapy. The growing global concern of antimicrobial resistance has renewed interest in bacteriophage therapy as a host-specific and effective alternative. Therefore, the present study was undertaken to determine the prevalence of staphylococcal mastitis in cattle and to comparatively evaluate the therapeutic efficacy of intramammary antibiotics and bacteriophages under different treatment regimens.

The study was conducted over six months period, cattle were screened for mastitis and selected for study using the California Mastitis Test (CMT) and udder palpation scores. Milk samples were collected aseptically and cultured for *Staphylococcus* spp. Bacteriophages were isolated from environmental sources and amplified for therapy. Clinical signs, udder palpation, CMT score, milk pH, and cure rate were recorded pre- and post-treatment, and data analysed statistically for treatment efficacy.

A total of 240 lactating cattle were screened for mastitis. Prevalence study showed overall 23.75% prevalence, with 12.91% cases due to staphylococcal mastitis, animals aged 6–10 years with ≥ 4 parity and during early lactation, quarter-wise 6.43%, with the right hind quarter most affected.

Twenty-four staphylococcal mastitis-positive cattle were randomized into four treatment regimens. Intramammary cefoperazone sodium and a *Staphylococcus*-specific bacteriophage cocktail were used alone or in combination. Bacteriophage therapy followed by antibiotic group (T2) showed the fastest and most effective recovery as compared to other groups, with binary logistic regression indicating a significantly lower odds of infection antibiotic-only treatment (OR = 0.038, $p < 0.05$) indicating bacteriophage therapy as an effective adjunct or alternative to antibiotics, offering a promising strategy to address antimicrobial resistance in dairy cattle.

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Author Index

S.NO	NAME OF AUTHOR	PAGE NO.
1	AAKANKSHA MEVAL	198
2	AAKASH VARMA	46
3	AAKRITI SINGH	150
4	AASHISH	116
5	ABHAVYA SHUKLA	199
6	ABHISHEK MESHRAM	268
7	ABHISHEK TIWARI	117
8	ACHAL KUMAR	82
9	ACHALA SINGH	73
10	ADARSH SINGH JADON	57
11	ADITYA PRATAP	269
12	AJAR ANUPAM PRADHAN	261
13	AKANKSHA AGRAWAL	118
14	AKANKSHA MISHRA	151
15	AKSHITA SONI	152
16	ALOK KUMAR	58
17	AMIT PRATAP SINGH	200
18	ANAMIKA JAIN	201
19	ANIMESH PAUL	83
20	ANJALI JAIN	202
21	ANJALI YADAV	153
22	ANJAN PAL	226
23	ANKIT KUMAR CHOUBEY	26
24	ANKIT KUMAR SINGH	1
25	ANKITA DWIVEDI	98
26	ANKITA NEMU	227
27	ANOOP SUNARTHY	59
28	ANSHUMAN NIGAM	228
29	ANUBHUTI SINGH	74
30	ANUPAMA SEKHAR	262

S.NO	NAME OF AUTHOR	PAGE NO.
31	ANUSHREE JAIN	27
32	APRAJITA JOSHI	229
33	ARPAN MUKHERJEE	154
34	ARPANA PUROHIT	203
35	ARPIT AJAY JOGLEKAR	131
36	ARPITA NAMDEO	204
37	ASHISH GUPTA	230
38	ASHISH VERMA	155
39	ASHWANI KUMAR	132
40	ASHWINI WAGHMARE	156
41	ASI KHANDELWAL	231
42	ATUL KUMAR	60
43	AVINASH PANDEY	47
44	AYUSHI	61
45	AYUSHI CHOURASIA	270
46	AYUSHI SHARMA	232
47	AYUSHI SONI	2
48	BANTI YADAV	233
49	BHAGYASHRI SOUMYA NAYAK	157
50	BHARTI GAUR	28
51	BHAVANA CHOUDHARY	99
52	BIBHUTI BHUSANA MEHER	119
53	BRIJESH SINGH MEHRA	234
54	BRIJESHWAR SINGH	158
55	DAU RAM	205
56	DEBABRATA DASH	137
57	DEEESHKHA KEDARE	235
58	DEEKSHA GUPTA	48
59	DEEKSHA PATEL	236
60	DEEPAK MISHRA	75
61	DEEPAK SAH	237
62	DEEPAK SINGH	3
63	DEEPEESH NIMJE	238
64	DEEPIKA PATHAK	159
65	DEEPTI SAHU	120
66	DEVENDRA PARGANIHA	29
67	DEVYANI RAJPUT	206
68	DHEERAJ KUMAR	84

S.NO	NAME OF AUTHOR	PAGE NO.
69	DHRUV KUMAR PATEL	4
70	DIKSHA	160
71	DIKSHA SINGH	30
72	DIPESH BARDE	31
73	EKANSH AGRAWAL	100
74	GAMI PRATIKSHA KANTILAL	32
75	GANJAHALLI VANI	5
76	GARIMA STEPHEN	101
77	GAYATRI DEVI	271
78	GULAFSHA BAIG	62
79	HARSH VARDHAN SINGH	161
80	HARSHITA SINGHAI	207
81	HARSHNA VISHWAKARMA	208
82	HEMANT SINGH	263
83	HIMANSHU SHARMA	133
84	HIMANSHU KUMAR BHATT	21
85	HRITAMBHRA DESHMUKH	162
86	INDU RANI	121
87	ISHA JAIN	163
88	JAHNAVI SHARMA	138
89	JAISING TOPPO	209
90	JANGAM DEEPIKA	76
91	JAYSHREE	122
92	JYOTI BIDOLYA	77
93	JYOTI LOHARE	6
94	JYOTSNA DHUBKARYA	164
95	KAINAT USMANI	165
96	KAISAR JAN	239
97	KAMNI PAWAR	240
98	KARAN SINGHAI	49
99	KASHMI SHARMA	139
100	KAUSTAV KRISHNA MALAKAR	241
101	KAVITA MAKWANA	123
102	KHOKAN PARIA	33
103	KHUSHI JAIN	272
104	KHUSHWANT SINGH	22
105	KIRTI GUPTA	124
106	KOMAL PURSHARTHI	125

S.NO	NAME OF AUTHOR	PAGE NO.
107	KRUPA ROCHIT SINGHAL	140
108	KULDEEP GAULIYA	166
109	KULDEEP NAMDEO	126
110	KULESHWAR SAHU	210
111	LAKSHYA DHARAMDASANI	167
112	LALIT KUMAR VERMA	7
113	LAXMI KURMI	168
114	MANAN GULATI	134
115	MANISH GADEKAR	8
116	MANISH SHARMA	211
117	MANISH KUMAR MANJHI	169
118	MANISHA PRIYADARSINI	242
119	MANOHAR CHOUDHARY	127
120	MEENAKSHI SHRIVASTAV	102
121	MEENAL BAGHEL	9
122	MEGHA VARMA	243
123	MOHINI NAYAK	50
124	MOHINI MITTAL	34
125	MOHINI SHERAWAT	170
126	MOHIT KUMAR	85
127	MONA KRITI	103
128	MUNAZZAH FATIMA ANSARI	244
129	MUSKAN JAIN	10
130	NABASHREE CHAKRABORTY	35
131	NABENDU BHUI	63
132	NABOMITA PAUL	171
133	NAFISA MUSTAFA HUSSAIN	36
134	NAMRATA DWIVEDI	11
135	NARENDRA BANKIRA	212
136	NEERAJ BHATT	245
137	NEHA KUMARI	64
138	NEHA VISHWAKARMA	37
139	NEHA RAMESH GIRHE	128
140	NIDHI MAHARWAL	172
141	NIHARIKA SINGH	173
142	NIKHIL KUMAR PANDEY	51
143	NIKITA MOHANTA	86
144	NIKITA SHARMA	174

S.NO	NAME OF AUTHOR	PAGE NO.
145	NIKUNJBHAI JAYMALBHAI BHEDA	135
146	NILANJANA DAS	175
147	NISHA PRAJAPATI	264
148	NISHI JAIN	104
149	NISHI MISHRA	12
150	NITISH KUMAR MAHALA	176
151	NITYA SANGHVI	52
152	PARUL AGGARWAL	38
153	POOJA VERMA	92
154	POONAM BAJORIA	87
155	POONAM KUMARI PATHAK	105
156	PRABHA DEVI SHARMA	177
157	PRACHI CHACHONDHIA	65
158	PRAGYA KUMARI	129
159	PRAHLAD SINGH PARASTE	106
160	PRAMOD PATIDAR	178
161	PRANSHI GUPTA	179
162	PRATEEK SARANGI	66
163	PRATIBHA BALIRAM MADBHAGAT	180
164	PRAVALIKA ANNAPUREDDY	273
165	PRAVEEN TYAGI	246
166	PRAVEEN KUMAR LITORIYA	247
167	PRINCE MALIK	39
168	PRIYAM CHOUHAN	53
169	PRIYANK AGRAWAL	93
170	PRIYANKA GUPTA	107
171	PRIYANKA PAYAL	181
172	PRIYANSHI MANTRI	248
173	PRIYANSHI TIWARI	249
174	PRIYANSHU NEMA	213
175	PURNA BHIKHUBHAI KUKADIYA	88
176	PURNIMA TRIPATHI	141
177	RAGINI SINGH	182
178	RAGNI DUBEY	142
179	RAHUL SINGH	214
180	RAJEEV RNAJAN DWIVEDI	67
181	RAMESH AVALA	40
182	RANU SINGH	183

S.NO	NAME OF AUTHOR	PAGE NO.
183	RASEL MONDAL	68
184	RENUKA MEWADE	274
185	RICHA JAIN	54
186	RICHA RAJAWAT	130
187	RITA TYAGI	275
188	RITU ARYA	89
189	RITU PANDEY	13
190	RIYA CHAUDHARY	184
191	RIYA MISHRA	14
192	RIYA ROY	250
193	ROHAN SHRIVASTAVA	185
194	RUCHI CHANDSURYA	265
195	RUPANSHI SAHU	215
196	SADAF ANSAR	143
197	SAI SARBANI MUND	108
198	SAIMA SHARFUDDIN	144
199	SAKSHI SHRIVASTAVA	69
200	SAKSHI SARATHE	94
201	SAMIKSHA RAJPOOT	251
202	SANJEEV KUMAR	252
203	SANJIVANI MANIKRAO JOSHI	186
204	SANOBER KALAM	109
205	SANTOSH KUMAR	90
206	SARGAM SONI	216
207	SASWATA TALUKDAR	253
208	SATYABHAVANA SAKRE	217
209	SATYAM DUBEY	254
210	SATYAM YADAV	218
211	SATYAMSHYAM VISHWAKARMA	219
212	SEEMA SAHU	145
213	SHAILJA SINGHAL	187
214	SHALINI MISHRA	15
215	SHALINI CHATURVEDI	16
216	SHANIYA ZEHRA	266
217	SHANKAR GHOTIA	23
218	SHARANJEET SINGH	255
219	SHASHANK KUMAR	256
220	SHEEBA REHMAN	188

S.NO	NAME OF AUTHOR	PAGE NO.
221	SHEKHAR CHANDRA PANDEY	257
222	SHIKHA UPADHYAY	17
223	SHILPEE CHAUHAN	24
224	SHIVAM KUMAR KORI	220
225	SHIVANGI BIDOLIYA	258
226	SHIVANGI VYAS	41
227	SHIVANI PANDEY	25
228	SHIVIKA CHOUKSEY	276
229	SHOBHANA SONI	110
230	SHREYA DIXIT	95
231	SHRUTI SINGH	146
232	SHRUTI UMARVAISH	189
233	SHRUTI VYAS	259
234	SHUBHAM AHIRWAR	18
235	SHUBHAM MORE	55
236	SHUBHAM YADAV	260
237	SHUBHANGI NEMA	221
238	SHUBHANGI PORWAL	70
239	SHWETA TIWARI	111
240	SIDDHARTH PAL	190
241	SK RAMEEJ RAJA	191
242	SNEHA BIBYAN	112
243	SNEHA WAT	267
244	SNEHAL PUROHIT	42
245	SONALI SHARMA	113
246	SONALI SINGH	19
247	SONGTHET CHINNUNNEM HAOKIP	78
248	SOUMYA KUNDU	79
249	SOUMYA RANJAN PANDA	43
250	SRIJA ROY	96
251	SRIMANTA GOGOI	44
252	SUMIT KUMAR	192
253	SUNANDA SAMANTA	193
254	SUPRIYA GUPTA	114
255	SURBHI TOMAR	222
256	SVASTIK JAISWAL	45
257	SWATI RATHORE	223
258	SWATI SAHU	224

S.NO	NAME OF AUTHOR	PAGE NO.
259	TEENA YADAV	115
260	TILESHWAR SAHARE	147
261	TRUPTIMAYEE BARIK	194
262	VANDANA GUPTA	277
263	VARTIKA SHRIVASTAVA	91
264	VEENA N BHAJANTRI	80
265	VEERENDRA KUMAR PATEL	20
266	VIJAY PRATAP AHIRWAR	225
267	VIKAS PAL VEELON	195
268	VIKAS SUDAM GORE	81
269	VINEETA NA SHRIVASTAVA	71
270	VIPIN KUMAR GAUTAM	278
271	VIRENDRA SURAGE	56
272	VISHESH KUMAR	72
273	VIVEK VERMA	196
274	VRUSHALI D PATIL	148
275	YOGESH YADAV	149
276	YUGAL VIJAY BHAISARE	136
277	YUSRA MARIAM	97
278	ZIRHA SALEEM	197





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