International Conference on Innovation and Emerging Technologies 2025

Exploring technologies for a smarter and sustainable future

Proceedings

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Preface

The Fifth International Conference on Innovation and Emerging Technologies (ICIET 2025), organized by the Faculty of Technology, University of Sri Jayewardenepura, provides a platform for researchers, academics, and industry professionals to present and discuss advancements in emerging technologies for a smarter and sustainable future. A key highlight of the conference is the ICIET 2025 Industry Conclave, a dynamic forum that brings together academia and industry to foster meaningful dialogue, explore collaborative innovation, and unlock new opportunities for technology transfer, commercialization, and applied problem-solving for real-world challenges.

ICIET 2025 features contributions across multiple disciplines, including biosystems technology, information and communication technology, civil and environmental technology, materials and mechanical technology, and science for technology. By linking cutting-edge research with practical industry insights, the conference and its Industry Conclave collectively promote collaboration, knowledge exchange, and research-driven solutions that support sustainable development and national technological advancement.

We extend our heartfelt gratitude to all authors, reviewers, session chairs, and industry partners for their invaluable contributions, which have been instrumental in making ICIET 2025 and the Industry Conclave a reality. Your collective support continues to reinforce the Faculty's focus on fostering innovation, collaboration, and academic excellence.

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ICIET 2025 Industry Conclave Agenda

Time	Item
4:30 pm	Registration
4:55 pm	University Anthem
5.00 pm	Welcome Address by the Dean, Faculty of Technology
5.15 pm	Address by the Vice Chancellor
5:30 pm	Keynote Speech
5:50 pm	Entertainment Event I
5:55 pm	Presentation: Faculty Programs and Industry Linkages
6.10 pm	Industry- Academic Networking Session
6:50 pm	Entertainment Event II
6:55 pm	Panel Discussion
7.35 pm	Vote of Thanks
7:40 pm	Dinner and Networking

Message from the Vice-Chancellor

It is with immense pleasure that I extend my heartfelt congratulations on the successful organization of the 5th International Conference on Innovation and Emerging Technologies (ICIET) 2025, hosted by the Faculty of Technology, University of Sri Jayewardenepura. Scheduled from November 25th to 27th, 2025, under the theme "Exploring Technologies for a Smarter and Sustainable Future", ICIET 2025 serves as a great platform for sharing knowledge on smart technologies applied across various fields. The conference aims to develop interdisciplinary collaboration and innovation, addressing the pressing challenges of our time. This year's conference features 16 specialized tracks, attracting participation from both local and international researchers, reflecting the dynamic nature of contemporary technological advancements.

I would like to commend the dedicated efforts of the academic and non-academic staff of the Faculty of Technology for their exceptional work in organizing this prestigious event. Their commitment has once again set a standard of excellence, reinforcing the Faculty's pivotal role in advancing the nation's technological capabilities.

I also wish to express my sincere appreciation to the General Chair of ICIET 2025, Dean of the Faculty of Technology, Prof. Renuka Nilmini Liyanage, and the members of the conference organizing committee for their steadfast dedication in bringing this event to fruition.

As Vice-Chancellor, I am immensely proud of the Faculty's accomplishments and encourage them to continue their remarkable efforts, further expanding their scope in the years to come. I extend my best wishes to all participants and presenters, and I hope that ICIET 2025 proves to be a rewarding and insightful experience for everyone involved.

Senior Professor M. M. Pathmalal
Vice-Chancellor
University of Sri Jayewardenepura.

Message from the General Chair

It is with great enthusiasm that I welcome you to the 5th International Conference on Innovation and Emerging Technologies (ICIET) 2025, organized by the Faculty of Technology, University of Sri Jayewardenepura. ICIET has steadily grown into a premier platform for sharing knowledge, fostering creativity, and promoting technological advancements that have the potential to transform society.

The theme of ICIET 2025, "Exploring Technologies for a Smarter and Sustainable Future," emphasizes the importance of innovative approaches to address the complex challenges of today's rapidly evolving world. Through its 16 specialized tracks, the conference brings together researchers, practitioners, industry leaders, and students to exchange insights, present original research, and explore collaborative opportunities.

This conference aims to provide a vibrant environment for dialogue and interaction, encouraging participants to engage in meaningful discussions, network with peers, and gain inspiration from pioneering work across diverse fields of science, engineering, and technology. The keynote presentations and panel discussions will offer unique perspectives on emerging trends, breakthroughs, and applications that shape the future of innovation.

ICIET 2025 would not have been possible without the dedication and hard work of the organizing committee, the academic and administrative staff of the Faculty of Technology, and the continued guidance of the University leadership. I also extend my sincere appreciation to our sponsors and partners, whose support ensures the success of this event.

I congratulate all presenters and participants for their contributions, and I hope that ICIET 2025 serves as an enriching platform for learning, collaboration, and inspiration, fostering the next generation of innovative thinkers and technology leaders.

Professor Renuka Nilmini Liyanage
BSc (Hons) (Colombo), PhD (Cardiff)
Dean/General Chair - ICIET 2025
Faculty of Technology,
University of Sri Jayewardenepura.

Keynote Speaker

Prof. Rahula Anura Attalage (BSc (Engineering), MEng, DEA, PhD)

Prof. Rahula Attalage is the Pro Vice Chancellor Academic at the Sri Lanka Institute of Information Technology (SLIIT). He is Professor Emeritus, University of Moratuwa, former Deputy Vice Chancellor, and former Senior Professor in Mechanical Engineering of the University of Moratuwa. He is a Chartered Engineer of the Institution of Engineers Sri Lanka, Corporate Member, and a past President of Sri Lanka Energy Managers Association, Fellow and Past President of Lanka Association of Building Services Engineers (LABSE), Fellow National Academy of Sciences Sri Lanka. Prof. Rahula Attalage has served as a visiting faculty member of AIT, Thailand, and as a Visiting Professor at Toyohashi University of Technology in Japan, and has been involved in higher education and research for the past 35 years. He has also held the posts of member of the commission of the Public Utilities Commission of Sri Lanka, Chairman of the National Institute of Fisheries and Nautical Engineering, and member of the board of directors of the National Engineering Research and Development Center, and a member of many committees on developing energy performance standards. He is currently a member of the University Grants Commission and a board member of the urban development authority. He has published more than 85 journal and conference papers, and is a recipient of the Presidential Award for Scientific Publications on several occasions. He was bestowed the honorary distinction for an academic “Order of the Academic Palms”, by the Government of France in 2018.

Conference Tracks

Agricultural Technologies for Sustainability

Applied Information Systems, Strategy, Societal Impacts

Artificial Intelligence and Data Science

Automotive Engineering

Biotechnology, Bioengineering, and Industrial Bioprocessing

Building Construction and Infrastructure Technology

Communication and Networking Technologies

Energy, Environment, and Sustainability

Food Security, Nutrition, and Processing Technology

Geo Resources, Geo Environment, and Geotechnics

Industrial Electronics

Interactive Media Technologies

Materials Engineering and Process Technology

Mechatronics, Robotics, and Automation

Science for Technology

Technology Education and Management

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Agricultural Technologies for Sustainability

Nutritional and Amino Acid Profiling of Immature Palmyrah (*Borassus flabellifer*) Leaves as a Potential Feed Ingredient

G. Thibiha[a,*], M.A.K.D. Mallikarachchi[a], S. Maathumai[a], A.M.G.N. Rathnayake[b], and V.P. Ellepola[a]

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Abstract

Palmyrah (*Borassus flabellifer*) is a prolonged palm species widely distributed in tropical regions, where its potential as a sustainable protein source remains largely unutilized. This study aimed to evaluate the nutritional and amino acid composition of immature palmyrah leaves to determine their suitability as an alternative feed ingredient. Leaves aged between 30–40 months were harvested from the Jaffna Peninsula, Sri Lanka, and exposed to chemical and amino acid analysis. High-Performance Liquid Chromatography and standard biochemical assays were used to quantify amino acid content and assess nutritional compositions. The crude protein content of the leaf samples was determined to be 12.36 g/100 g, with ash content at 10.24 g/100 g and gross energy value measured at 3.61 Mcal/kg. Amino acid profiling showed the presence of histidine (198.9 mg/kg), aspartic acid (150.2 mg/kg), threonine (132.9 mg/kg), alanine (80.6 mg/kg), cystine (316.1 mg/kg), phenylalanine (120.4 mg/kg), and leucine (78.6 mg/kg) of dry weight. However, essential amino acids such as lysine and methionine were not detected, indicating that palmyrah leaf is not a complete protein source when used in isolation. But its moderate protein content and important amino acid presence support its use as a supplementary component in livestock feed formulations, particularly when combined with other protein-rich ingredients. These findings provide the first scientific proof of amino acid profile as a foundation for further research into optimizing palmyrah leaf utilization in animal feed and other biotechnological applications.

Keywords: amino acid profiling; animal feed; palmyrah leaf; protein source

Mechanochemical Activation of Apatite with Oxalic Acid: A Green Route to Controlled Phosphorus Release

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Abstract

Phosphorus scarcity and inefficient fertilizer use pose a threat to food security, necessitating the development of sustainable alternatives to conventional soluble fertilizers. This study evaluated whether oxalic acid-mediated mechanochemical grinding can enhance phosphorus availability from Eppawala Rock Phosphate (ERP) for agricultural application. ERP was ground with oxalic acid at five ratios (1:0.2 to 1:1 ERP: OA) and characterized using X-ray diffraction, Fourier Transform Infrared Spectroscopy, and Scanning Electron Microscopy. Water and soil incubation studies (n=3, completely randomized design) were conducted to assess phosphorus release over 50 days using UV-Vis spectrophotometric analysis. Kinetic modeling employed zero-order and pseudo-first-order models. Pot trials (n = 6) evaluated agronomic performance in chili (*Capsicum* sp.) at 50 and 100 kg P/ha rates. Mechanochemical treatment converted hydroxyapatite to monetite ($CaHPO_4$) and calcium oxalate, increasing water-soluble phosphorus from 0.001% (untreated ERP) to 96-99% in optimal formulations (OA: ERP-0.9:1 to OA: ERP-1.2:1), comparable to triple superphosphate (TSP, 91.69%). In soil incubation, OA-0.9 released 51.6% of applied phosphorus over 50 days versus TSP's 13.6% ($p<0.05$), following biphasic release kinetics. This translated to exceptional agronomic performance: OA: ERP-0.9:1 (100 kg/ha) produced 92.24±1.51 g fresh chili pods per plant, 90% higher than TSP ($p<0.05$) and 1740% higher than untreated ERP. The germination index reached 209.76%, confirming phytostimulatory effects. Remarkably, the 50 kg/ha application achieved 79% of maximum yield with 58% higher phosphorus use efficiency than the 100 kg/ha rate. This green chemistry approach transforms low-grade domestic phosphate into a superior controlled-release fertilizer through benign processing, reducing import dependency and minimizing environmental losses through demand-synchronized nutrient release. The technology provides a replicable framework for sustainable phosphorus management in phosphorus-limited regions.

Keywords: mechanochemical modification; oxalic acid; phosphorus; rock phosphate

IoT-based Capsicum Plant Analysis Model using Machine and Deep Learning with an Autonomous Robot

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Abstract

Early prediction of plant growth and development is important for crop productivity and disease management. This study introduces a machine learning with a convolutional neural network (CNN) model and integrated IoT enabled robotics to revolutionize modern agriculture 4.0, specifically for capsicum cultivation. Capsicum plant images and disease types, along with simultaneous environmental parameters such as humidity, temperature, and soil moisture collected from agricultural fields, were used to train the model. A lightweight YOLO11n-based CNN model is employed for real-time classification of plant growth stages and disease detection, achieving a mAP at 50 of 0.733 and mAP at 50-95 of 0.426. Additionally, a Random Forest Regression model predicts harvesting timelines with high accuracy (R^2=0.9653) and a maximum deviation of 4-5 days in harvest prediction. All the collected data is visualized on a web-based dashboard, allowing users to monitor plant conditions in real time and simulate plant behavior under varying conditions. The autonomous robot integrates sensors and vision modules to automate data acquisition, while its navigation and obstacle avoidance capabilities facilitate efficient field monitoring and precision farming. This study introduces a novel integration of computer vision and machine learning for precise capsicum growth analysis and harvest prediction by addressing existing challenges in conventional farming practices.

Keywords: capsicum plant analysis; precision farming; machine learning; convolutional neural network; autonomous robot

Decoding Germination Stage Drought Tolerance and Genetic Diversity of Proso Millet (*Panicum miliaceum*) Genotypes in Sri Lanka using SSR Markers

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Abstract

Proso millet (*Panicum miliaceum*) is a drought-resilient and nutritious cereal, contributing the sustainable agriculture and food security. This study aimed to assess the drought tolerance at the germination stage and genetic diversity using Simple Sequence Repeat (SSR) markers among ten proso millet genotypes, including landraces collected from Thanamalwila, Jaffna, Sooriyawewa, Angunakolawewa, Wandama, and Weheragala, Sri Lanka, compared to three accessions from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Drought screening was conducted using a Completely Randomized Design with three replicates per accession under polyethylene glycol-induced osmotic stress of -0.5 MPa, along with a control setup. Drought tolerance was assessed ten days after germination using drought-responsive morpho-physiological parameters, including germination percentage (GP), shoot length (SL), root length (RL), and derived indices. Relative parameter analysis using Analysis of Variance and Tukey's test by R Studio (V4.2.1) revealed significant variability ($p<0.001$) among genotypes under drought stress. GP, RL, and seedling vigour tolerance index (SVTI) ranged from 72.3 to 89.7%, from 3.8 to 6.5 cm, and from 0.68 to 0.94, respectively. Landraces from Jaffna (WUDL3PM_2501) and Sooriyawewa (WUDL1bPM_2503) exhibited comparatively higher SVTI (65.43) and root length drought tolerance index (167.89) along with relatively higher values for other evaluated parameters, thereby outperforming most ICRISAT accessions. Genetic diversity analysis using five SSR markers produced 32 alleles among 10 genotypes with an average of 6.4 alleles per locus and polymorphic information content values ranged from 0.61 to 0.84. Unweighted pair group method with arithmetic mean clustering based on Nei's genetic similarity confirmed a differentiation between landraces and improved accessions, with WUDL3PM_2501 and WUDL1bPM_2503 occupying distinct genetic clusters. These findings indicate the presence of valuable drought-tolerant potential within local proso millet landraces, which can be utilized for future breeding programmes to develop drought-resilient varieties adapted for local climatic conditions.

Keywords: drought tolerance; germination; proso millet; simple sequence repeat markers

Wee Saviya: A Digital Platform for Enhancing Paddy Management in Sri Lanka

I.D. Hengoda*, W.A.H. Witharana, S.A.N.K. Senarath, G.A. Dhananjani, D.T.P. Dasanayake, and M.S. Madhubhashini

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Abstract

Sri Lanka's paddy sector, a critical pillar of rural livelihoods and food security, continues to face long-standing inefficiencies caused by manual operations, inconsistent data handling, and weak coordination among farmers, mill operators, and the Paddy Marketing Board. These limitations reduce transparency, delay decision-making, and weaken trust in public-sector management. This study investigates these operational challenges and proposes Wee Saviya, a digital platform designed to strengthen coordination, accountability, and efficiency in government-linked paddy management. Data for the study were collected through interviews with Paddy Marketing Board officers, mill operators, and over 30 farmers from key paddy-growing regions, complemented by field observations and document reviews of existing workflows. Findings from this analysis informed the design of Wee Saviya, a centralized digital platform connecting all stakeholders through modules for farmer and mill registration, real-time stock monitoring, digital quality recording, logistics coordination, mill mapping, and analytical reporting to support evidence-based planning. Preliminary evaluation through iterative testing indicated high usability and reliability, with automation projected to reduce inventory-related errors by about 40% and improve the timeliness of data reporting. Beyond operational efficiency, the system demonstrates how user-centered design and localized digital tools can enhance trust, inclusivity, and accountability within public agricultural programs. Future work will focus on extending the platform to support multi-crop management, integrating retail distribution tracking, and nationwide scalability. By linking field-level producers and government agencies through a unified data infrastructure, the study highlights Wee Saviya as a scalable model for agricultural digitalization that can contribute to national food-supply resilience and promote sustainable rural development in Sri Lanka and similar developing contexts.

Keywords: paddy management; digital platform; paddy marketing board; agricultural digitalization; Sri Lankan agriculture

Comparative Evaluation of Vegetative Growth Parameters in Selected Pepper (*Piper nigrum* L.) Cultivars in the Low Country Wet Zone

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Abstract

Black pepper (*Piper nigrum* L.) is the second most widely cultivated spice, primarily grown in the low and mid-country wet and intermediate agro-climatic zones. The Department of Export Agriculture has recently introduced three new hybrids: *Dingi Rala*, *Kohukumbure Rala*, and *Bootawe Rala*. Traditional varieties such as Panniyur-1, MB-12, and GK-49 remain widely cultivated. Among these, *Dingi Rala* is particularly popular among farmers. However, in some areas, farmers have experienced issues related to poor filling rates and inconsistent growth performance among these popular cultivars. This study was conducted as adaptive research with the objective of comparing the vegetative growth and survival rates of selected black pepper cultivars to determine the most suitable cultivar for the low-country wet zone. The experiment was laid out in a randomized complete block design with seven treatments, four replicates, and three blocks. Growth parameters such as plant height, number of nodes, number of leaves, number of lateral branches, internodal length, and number of surviving plants were measured at regular intervals during the vegetative stage and analyzed using Statistical Analysis System software. Among the evaluated cultivars, Panniyur-1 and GK-49 exhibited significantly superior vegetative growth characteristics, including higher average plant height, number of nodes, number of lateral branches, internodal length, and survival rates compared to other cultivars. GK-49 also recorded the highest number of leaves. In contrast, MW-21 exhibited the lowest performance across all measured parameters. These findings indicate that, at the vegetative stage, *Panniyur-1* and GK-49 are the most promising cultivars for black pepper cultivation in the low country wet zone due to their vigorous growth and adaptability.

Keywords: black pepper; cultivar evaluation; vegetative growth; survival rate; low country wet zone

Feeding and Drinking Behaviour, and Physiological Responses of Lactating Dairy Cows Supplemented with Effective Microorganisms

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Abstract

Effective microorganisms (EM) are a mixture of beneficial microbes that improve livestock performance, with proven changes in behavioral patterns in dairy cattle. Thus, this study was conducted to evaluate the effect of EM supplementation on behavioral patterns and physiological parameters of lactating dairy cows. Ten Jersey crossbred cows in same parity were randomly assigned to two treatments (n=5) using a completely randomized design. Cows received either total mixed ration (TMR) or EM-incorporated TMR (10 mL kg^{-1} TMR). Animals were fed twice daily for 12 weeks, with water provided ad libitum. Behavior observations were recorded as 2 hours of feeding events starting from the eighth week using a CCTV camera and analyzed using BORIS software to evaluate feeding, drinking, ruminating, and social behaviors. Physiological parameters, such as rectal temperature, heart rate, and rumen movements, were measured daily. The results indicated that EM supplementation significantly ($p<0.05$) increased frequency of feed intake (4.51±0.34 events) and water intake (1.82±0.31 events), and social behaviors, like licking other cows. Further, self-licking, ruminating, tail wagging, standing, lying, movements, and sniffing behaviors had no significant differences ($p>0.05$) between the treatment groups. Among the physiological parameters, rumen movements were significantly lower ($p<0.05$) in the EM-supplemented group (3.31±0.13 No. of palpations per minute) compared to the control group (4.08±0.13 No. of palpations per minute). However, rectal temperature and heart rate had no significant differences ($p>0.05$). These findings suggest that EM supplementation positively influences specific behavioral patterns, particularly those related to eating, drinking, and social interactions. Further, the absence of significant changes in rectal temperature and heart rate suggests that physiological homeostasis in lactating dairy cows remains unaffected.

Keywords: animal behavior; dietary modification; probiotics; sustainable farming

Design and Development of an Intelligent System for Irrigation Management

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Abstract

Conventional irrigation methods often lead to resource waste, long-term soil degradation, and limited yield improvements. While precision agriculture tools/technologies offer improvements in yield and resource use, their high costs and complexity make them inaccessible to resource-limited farmers. This study proposes an integrated, cost-effective IoT platform that automates irrigation via real-time environmental and soil data. The proposed architecture comprises a sensing node and a controller node that continuously monitor environmental and soil parameters, namely, temperature, humidity, light intensity, wind speed, atmospheric pressure, and soil moisture. The Penman-Monteith model was utilized to determine crop water requirements. These inputs were processed using a fuzzy logic controller to enable intelligent, automated control of irrigation. The system features a hybrid communication framework combining GSM, Wi-Fi, and LoRa technologies for robust and flexible data transmission ensuring its reliable operation. Trials were conducted on a tomato (*Solanum lycopersicum*) crop, and the system performance was evaluated through test cases focusing on irrigation timing accuracy, irrigation input, and communication reliability. Irrigation timing accuracy was assessed by comparing algorithm-generated events with the actual activation durations. Hence, for a target of 120 s, the system delivered 122 s, achieving irrigation timing accuracy of 98.6%. Drip-side water delivery showed a±4 mL deviation from the target irrigation input of 350 mL, which is calculated considering the crop water requirement estimation. These tests validated the correctness of both the automated control and the corresponding irrigation input. Further, LoRa-based wireless communication remained reliable up to 600 m at SF10, 125 kHz, with zero packet loss. The system supports FOTA updates, ensuring easy maintenance and scalability. Hence, this IoT-based, cost-effective irrigation management system serves as a practical and scalable solution for resource-limited farms due to its long-range and low-power operation. Also, it provides a real-time platform for automated irrigation that minimizes irrigation loss and promotes sustainable, data-driven agriculture.

Keywords: automated irrigation; IoT; irrigation timing accuracy; irrigation input; LoRa

Evaluation of Pre-emergent Herbicide Application by Autonomous Drone Spraying in Sri Lankan Paddy Fields

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Abstract

In Sri Lanka's paddy cultivation, herbicides are typically applied manually with knapsack sprayers, a method prone to poor target accuracy, chemical overuse, uneven coverage, and health risks. This study aims to optimize pre-programmed (autonomous) Unmanned Aerial Vehicles (UAV) spraying for herbicide application and compare its effectiveness for weed management (pre-emergent) in paddy fields with traditional knapsack spraying. A calibrated trial was conducted in an open field with a DJI AGRAS T25 drone, flown autonomously at 3 m height above the target area (32×32 m^2) with three droplet sizes as treatment settings of T1 (250 µm), T2 (350 µm), and T3 (450 µm). A knapsack spraying was also conducted manually by a human on the same target. Spray droplet deposition and drift from the autonomous drone spraying and manual spraying were recorded using 66 water-sensitive papers (2.6×7.6 cm^2) placed in 8 rows×11 columns within the target spraying area. Smartphone images of the water-sensitive papers were subsequently analyzed using ImageJ software to calculate spray coverage area percentage, droplet count, and droplet size. T3 (450 µm) achieved the best spraying coverage (4%) with minimum drift effect. Further, autonomous drone spraying was evaluated in a real paddy field pre-programmed drone settings of 450 µm droplet size and 2.5-3 m flying height for applying SOFIT (Pretilachlor) (pre-emergent herbicide) in four treatments dose levels D1 (70%), D2 (85%), D3 (100%), and D4 (115%) with the conventional knapsack method (D5) and control D6 (no chemical application). All the tested autonomous drone spraying doses showed similar ($p>0.05$) effects on weed control compared to conventional knapsack spraying. This study strongly encourages the possibility of precision herbicide application techniques to achieve effective weed control with reduced chemical input in future agricultural practices.

Keywords: pre-emergent herbicide; DJI AGRAS T25 drone; autonomous settings; precision spraying; sustainable agriculture

Effects of Organic Amendments on Growth Parameters of Plants with Different Root Systems

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Abstract

Plants with different root architectures may respond differently to organic amendments. Soil water repellency is a well-known phenomenon found on almost all continents under different land use types and climates. It causes water to persist on the soil surfaces for indefinite periods of time, hampering the spontaneous water insertion into the soil profile. However, the effects of biochar produced from water repellent material on shoots and roots growth of both plant root systems have not been extensively studied. Considering this limitation, the present study aimed to assess the effects of organic amendments (3% by weight) of *Casuarina equisetifolia* (CE) litter biochar: BCCE and cattle manure: CM, along with a control (surface soil without any amendment), on the dry weight of both shoot and root growth of tap-rooted *(Capsicum annuum)* and fibrous-rooted (*Eleusine coracana*) plants. CE leaf litter, a highly hydrophobic organic material, was used as the repellent material to produce biochar through pyrolysis. Pots were arranged in a completely randomized design with three replications. Dry weight (g) of both shoots and roots was recorded after 10 weeks, following oven-drying at 65 °C. Among the treatments, BCCE consistently showed the most beneficial effects on both the dry weight of shoots and roots of both plant types, followed by CM and the control, which exhibited the lowest plant performance. BCCE and CM showed 39% and 12% increment in dry weight of shoots, respectively than the control in tap-rooted plants. In fibrous-rooted plants, BCCE and CM showed 10% and 4% increment in shoots dry weight, respectively, compared to the control. The root dry weight showed increments of 77% and 16% in BCCE-amended soils with tap and fibrous-rooted plants, respectively. Tap-rooted plants benefited more from organic amendments (BCCE and CM) Fibrous-rooted plants also showed improvements, though the effects were less pronounced. BCCE can be a potential soil amendment. Further field-based investigations are recommended to validate the performance and long-term effects of BCCE.

Keywords: biochar; fibrous-rooted plants; organic amendments; tap-rooted plants; water repellency

Early Detection and Severity Assessment of Bacterial Leaf Blight (*Xanthomonas oryzae* pv. *oryzae*) in Rice (*Oryza sativa* L.) using NDVI-based Multispectral Imaging under Controlled Conditions

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Abstract

Bacterial Leaf Blight (BLB), caused by *Xanthomonas oryzae* pv. *oryzae*, limits rice production and causes severe yield losses. This study evaluated the potential of Normalized Difference Vegetation Index (NDVI) based multispectral imaging for early, non-destructive BLB detection under controlled conditions. The experiment was conducted under a plant cage at the Rice Research and Development Institute, Bathalagoda, Sri Lanka, using a two-factor Completely Randomized Design (CRD) with three replicates. Treatments included two bacterial isolates Bathalagoda (T1) and Bombuwala (T2) and a distilled-water control (T3) applied to three susceptible rice varieties (Bg 379-2, Bg 369, Bg 366). Images were captured at 100 cm canopy height using a DJI P4 Multispectral camera with one RGB and five multispectral sensors: Blue (450±16 nm), Green (560 ± 16 nm), Red (650±16 nm), Red Edge (730±16 nm), and Near-Infrared (840±26 nm). NDVI = (NIR-Red)/ (NIR+Red) was computed from images processed in MATLAB R2024b. Chlorophyll and NDVI were recorded every three days up to 15 days post inoculation (DPI), while the Disease Severity Index (DSI) was measured at 14 and 28 DPI using the 0–9 scale. NDVI declined significantly by six DPI ($\Delta NDVI \approx -0.18 \pm 0.02$; $p < 0.05$), preceding visible chlorosis. At 28 DPI, Bathalagoda showed higher DSI (100.0±2.4) than Bombuwala (95.9±2.1) in Bg 379-2. A strong negative correlation ($R^2 = 0.9885$; $p<0.001$) between NDVI and DSI confirmed NDVI as a reliable proxy for disease severity. Pathogen inoculation significantly reduced seed numbers ($p \leq 0.01$), indicating yield loss. This study shows that NDVI-based multispectral imaging enables early BLB detection before visible symptoms, offering a rapid tool for screening resistance in rice breeding programs. Field validation is recommended under natural conditions.

Keywords: bacterial leaf blight; chlorophyll; disease severity index; multispectral imaging; NDVI

Growth and Yield Evaluation of Paddy (*Oryza sativa*) under a Deep-water Culture Hydroponic System

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Abstract

This research looks at using Deep-Water Culture (DWC) hydroponic systems to grow paddy (*Oryza sativa*) as a sustainable option compared to traditional soil farming. The specific objectives of this study were to evaluate the growth and yield performance of paddy under different nutrient concentrations in a DWC system and to compare them with soil-based cultivation. A completely randomized design (CRD) was applied with four treatments (T1, T2, T3, and T4) and three replicates (n=3). We recorded growth and yield factors like plant height, number of tillers, leaf count, chlorophyll content, panicle count, and grain weight throughout the growing period under controlled conditions. The experiment was conducted from February to June 2025 using Albert's nutrient solution, maintaining EC between 1.5-2.5 mS cm^{-1} and pH between 5.5-6.6. Data were analyzed using ANOVA followed by the LSD test at $p<0.05$. The Bg 300 paddy variety was used, and seedlings were started in a nursery with coir media before being transplanted into the hydroponic units. The results showed significant differences ($p<0.05$) between treatments. Both the traditional soil method (T1) and the 130% fertilizer hydroponic treatment (T4) had better growth and yield. T1 had the highest average plant height (51.41 cm) and average panicle count (2.67), while T4 had similar results for average tillers (2.74), chlorophyll content (30.27 SPAD units), and average grain weight (4.98 g). This study highlights the novelty of applying DWC hydroponics for paddy cultivation in Sri Lanka, contributing new insights into sustainable and water-efficient rice production.

Keywords: paddy; *Oryza sativa*; hydroponics; deep-water culture; sustainable agriculture

Influence of Fertilizer-induced Substrate Electrical Conductivity Variations on Growth and Yield of Bell Pepper (*Capsicum annuum* L.) Grown in Coir-based Media under Controlled Environment

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Abstract

Bell pepper (*Capsicum annuum* L.) is a nutritionally and economically important crop in Sri Lanka. It is commonly cultivated under controlled environments due to its specific climatic requirements and market value. Effective fertilizer management and regular monitoring are important to optimize both growth and yield. This study aimed to evaluate the influence of fertilizer-induced variations in substrate electrical conductivity on the growth and yield of bell pepper (variety 'Inspiration') under controlled environmental conditions at Divulapitiya, Sri Lanka. Three electrical conductivity levels were tested using the same fertilizer combination; treatment 1: moderate (2-3 *mS/cm*), treatment 2: high (3-4 *mS/cm*), and treatment 3: low (1-2 *mS/cm)* three times in a randomized design. This fertigation was commenced four weeks after transplanting, with each plant receiving one liter of fertilizer solution per day. Electrical conductivity and pH values were monitored in the fertigation solution, substrate (1:1.5 ratio method) and drainage. Plant height was measured, while yield was assessed by recording the number and the weight of the pods until 15 weeks after transplanting. At the end of experiment, nutrient analysis of both the coir substrate and plant leaves was conducted. Data analysis was performed using R Studio. The results exhibited higher substrate and drainage electrical conductivity levels and reduced plant growth in the treatment subjected to high electrical conductivity. It showed a significantly low height while no significant difference was observed between other two treatments. Average number of pods (3-4) and average weight of pods (50-75 g) were not significantly different among all treatments. While showing similar variations in treatment 1 and treatment 3 in high growth and similar yield, suggesting low electrical conductivity may effective and higher electrical conductivity may despite the vegetative growth. Nutrient analysis revealed that high substrate electrical conductivity led to nutrient accumulation in the substrate and poor Potassium uptake by plants.

Keywords: bell pepper; controlled environment; electrical conductivity; fertilizer; nutrients

Evaluation of Bioherbicide Formulations Derived from Natural Plant Extracts for Sustainable Weed Control in Rice (*Oryza sativa* L.) Cultivation

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Abstract

Weeds represent one of the most critical biotic constraints in rice cultivation, particularly during early developmental stages, resulting in severe yield losses. The exploration of allelopathic interactions among plants offers an environmentally sustainable alternative for weed management, reducing dependence on synthetic herbicides that often cause hazardous effects. This study investigated the efficacy of bio-herbicidal formulations derived from allelopathic plant extracts applied at pre- and post-emergence stages to suppress weed populations without adversely affecting rice performance. Aqueous extracts were prepared from allelopathic plants from two families, P1 (family *Apocynaceae*) and P2 (family *Sapindaceae*). Their mixtures: C1 (P1 25%: P2 75%), C2 (P1 50%: P2 50%), and C3 (P1 75%: P2 25%) were formulated at 120 g/L concentration with adjuvants to enhance activity. The improved Sri Lankan rice variety, Bg360, was co-cultivated with weed seeds at a 1:1 ratio in paddy soil-filled pots, arranged in a randomized complete block design with three replications. Each bio-herbicide formulation (10 mL) was applied once per pot at pre-emergence (2 DAS), early post-emergence (7 DAS), and post-emergence (21 DAS). Weed suppression was evaluated through weed count, species composition, height, and dry weight, while rice performance was assessed by seedling survival and growth attributes. Data were analyzed by analysis of variance and the Kruskal-Walli's test using IBM SPSS Statistics. Among all treatments, formulation C2 exhibited the highest efficacy, reducing total weed count by 68.8% at pre-emergence and 88.1% at post-emergence, while decreasing weed species richness by 70%, height by 50%, and dry weight by 25% after post-emergence applications. Moreover, C2 selectively eliminated 100% of broadleaf and 85% of sedges without negatively influencing rice growth. These findings demonstrate C2 as a promising post-emergent selective bio-herbicide with strong potential for sustainable rice weed management through targeted suppression of broadleaf and sedges, aligning with environmentally responsible agricultural practices.

Keywords: allelopathy; plant extracts; bio-herbicide formulation; sustainable weed management

Green Synthesis of Nickel Nanoparticles from Panicum Maximum Leaf Extract, Characterization and its Effect on Early Seedling Growth *in vitro*

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Abstract

Green synthesis of metallic nanoparticles represents a sustainable approach to nanomaterial production, avoiding toxic chemicals and hazardous byproducts associated with conventional methods. This study investigated the eco-friendly synthesis of nickel nanoparticles (NiNPs) using Panicum maximum leaf extracts, which are rich in bioactive compounds that effectively reduce metal ions and stabilize nanoparticles. Fresh P. maximum leaves were collected, dried at 35-40 °C, and extracted using deionized water at 60 °C for 2 hours. NiNPs were synthesized by mixing 50 mL of 0.1 M Nickel (II) nitrate hexahydrate with 20 mL leaf extract, adjusting pH to 10 with NaOH, followed by calcination at 400 °C. Comprehensive characterization using UV-Visible spectroscopy confirmed nanoparticle formation with characteristic absorption at 209 nm, while FTIR analysis revealed Ni-O stretching vibrations between 552.32-618.10 cm^{-1}. XRD analysis showed cubic crystal structure with peaks at (111), (200), (220), and (222) planes, consistent with standard NiO diffraction data. In-vitro germination studies using seven concentration treatments (46.88-3000 µg/mL) of NiNPs on *P. maximum* seeds demonstrated significant dose-dependent effects on plant growth parameters. 3000 µg/mL and 1500 µg/mL produced optimal results, with 3000 µg/mL achieving the highest root length (30 mm) and superior fresh weight accumulation compared to lower concentration treatments. Statistical analysis revealed significant differences between treatment groups, indicating that moderate to high NiNPs concentrations enhance Panicum maximum growth, possibly through improved nutrient uptake mechanisms and cellular metabolic processes. These findings demonstrate the successful green synthesis of stable NiNPs and their potential application as sustainable growth enhancers in forage grass cultivation, supporting environmentally friendly agricultural practices.

Keywords: green synthesis; nickel nanoparticles; nanoparticle characterization; *Panicum maximum*; seed germination

Integration of Novel Organic Foliar Fertilizer Application for Enhance Production of Tea (*Camellia sinensis* L.) in Sri Lanka

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Abstract

Tea (*Camellia sinensis* L.) is a globally significant crop, and Sri Lanka is recognized as a leading producer. Tea cultivation requires a continuous nutrient supply for optimal shoot production and quality enhancement. However, the use of inorganic fertilizers only affects negative impacts on soil health and environmental sustainability. Therefore, this study was conducted to develop and evaluate effect of novel organic foliar fertilizer application using refuse tea, cow dung, Gliricidia leaves, aloe vera juice, sugarcane juice, and cow urine on the yield parameters of tea. The experiment was laid out using a Randomized Complete Block Design (RCBD) with twenty replicates**,** consisting of eight treatments: T1-1:5% (v/v) of formulated organic fertilizer, T2-1:10% (v/v) formulated organic fertilizer, T3-1:15% (v/v) formulated organic fertilizer, T4-No fertilizer (Control), T5-Inorganic fertilizer+T1, T6-Inorganic fertilizer+T2, T7-Inorganic fertilizer+T3 and T8-Inorganic fertilizer only (TRI recommended). Two leaves with a bud were plucked weekly after each foliar application to measure shoot weight and number of shoots and that data shown statistically significant difference ($p<0.05$) among the tested treatments. T5 recorded highest shoot weight (20.2±6.7 g) and shoot number (18±5.5), while the T4 recorded the lowest values (5.2±2.1 g and 6.4±2.2) respectively. Furthermore, sole application of organic fertilizer and inorganic fertilizer shown lower shoot weight and lower number of shoots compared to integration of organic and inorganic fertilizers applications (T5, T6, and T7). In addition to that, newly developed organic foliar fertilizer shown notable concentrations of nitrogen (2.02 g/L), potassium (1.02 g/L), and phosphorus (1.26 g/L). Therefore, this study can be concluded that, integration of inorganic fertilizer (TRI recommended) with the formulated organic foliar fertilizer (1:5% (v/v)) enhance yield parameters of tea.

Keywords: *Camellia sinensis*; inorganic fertilizer application; organic foliar fertilizer application; yield of tea

Evaluation of Fish Hydrolysate-based Liquid Fertilizer on the Growth and Yield of Okra (*Abelmoschus esculantus* L.) and Spinach (*Basella alba*)

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Abstract

Organic fertilizers derived from natural sources are increasing crop productivity while minimizing environmental impacts. This study aimed to investigate the effect of fish hydrolysate-based liquid fertilizer (FHF) on the growth and yield of okra and spinach and to determine the optimal application rate for these widely cultivated leafy and fruit vegetables in Sri Lanka. Treatments in this pot experiment were organized in a Randomized Complete Block Design with six replicates. All seven treatments were arranged as C-Control, C+NPK fertilizer, T1-1%, T2-2%, T3-3%, T4-4%, and T5-5% (v/v) of FHF as a Foliar Spray. Data were analyzed by one-way Analysis of Variance, and Mean separation was done using Turkey's test at $p<0.05$ as a significance level. The results indicated that for okra, the highest values for parameters were obtained in the C+ treatment, such as plant height (94.34±0.48 cm), number of pods per plant (12.2±0.84), yield per plant (311±15.17 g), and even days to first flower (54±0.45). Thereafter, T5 treatment revealed improved results compared with other FHF treatments, such as the lowest days to first flower (49±0.45), number of pods per plant (8.4±0.89), and yield per plant (202±2.74 g), but T4 treatment showed the highest plant height (82.64±0.42 cm) compared with T5. For spinach, compared with FHF treatment, C+ treatment showed improved performance, such as plant height (77.22±0.77 cm), number of leaves per plant (48.2±1.10), leaf length (16.72±0.83 cm), number of branches per plant (8.4±0.55), and yield per plant (387±5.7 g). But among FHF treatments, T3 showed the best performance, including plant height (75.3±1.44 cm), number of leaves per plant (30.2±0.84), leaf length (15.34±1.10 cm), number of branches per plant (7.2±2.17), and yield per plant (274.2±3.96 g). Overall, the results suggest that the C+treatment performed best, while foliar application of FHF, especially at 5% for okra and 3% for spinach, also showed good potential as an eco-friendly and sustainable alternative to chemical fertilizer.

Keywords: fish hydrolysate; liquid fertilizer; okra; spinach; growth and yield performance

Effect of Tamarind (*Tamarindus indica*) Seed Kernel Powder Incorporation on the Quality of Fiber-enriched Chicken Patties

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Abstract

Consumers are demanding health-benefit-integrated meat products. Tamarind seed (*Tamarindus indica*) is an underutilized crop enriched with nutritional and functional properties. Therefore, the target of this study was to develop a fiber-enriched chicken patty incorporated with tamarind seed kernel powder (TSKP) and analyze its physicochemical properties. The standard methodology of chicken patties production was followed, with TSKP incorporated at the levels of 0% TSKP (T1), 2% TSKP (T2), 4% TSKP (T3), and 6% TSKP (T4) (w/w). All other ingredients remained constant across treatments, except that the amount of chicken varied according to the TSKP level. In T1, wheat flour was used instead of TSKP. Proximate and physicochemical analyses were determined. A sensory evaluation was done using the nine-point hedonic scale on 30 panelists. Data were analyzed using SPSS statistical software version 6.0.10 with one-way ANOVA and Duncan test. According to the sensory evaluation, the chicken patties prepared with 4% TSKP and 6% TSKP recorded the highest consumer preference. The physicochemical properties such as cooking loss and emulsion stability were significantly affected over the T1($p<0.05$); meanwhile, significant differences among the treatments were recorded during storage period (-18 °C). Notably T3 and T4 maintained emulsion stability and cooking yield above 91% throughout the storage period. TSKP incorporated chicken patties showed higher proportions of protein & fiber content compared to control sample, except for moisture and fat content. Most specifically, higher dietary fiber content was observed in 6% TSKP patties (3.98±0.3%) compared to the control sample (1.01±0.01%) on the last day of the storage period. In addition, the protein content of 6% TSKP patties (19.15±0.05%) was higher than that of the T1 sample (15.12±0.02%). At the consumer level, T3 and T4 performed well in terms of taste, aroma, flavor, color, tenderness, and juiciness. In conclusion, 4% and 6% tamarind seed kernel incorporated chicken patties were identified as superior formulations compared with others. Therefore, they could be commercialized at an acceptable price.

Key words: tamarind seed kernel powder; physicochemical; sensory evaluation; chicken patties

Machine Learning-based Early Detection of Contamination in Tissue Culture

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Abstract

Early detection of contamination helps prevent widespread culture loss in plant tissue culture, reduces remediation expenses by enabling targeted interventions rather than full batch re-culturing. Currently, laboratories rely on conventional contamination detection methods, which are labor-intensive, subjective, time-consuming, and prone to errors. This research aims to develop an RGB imaging-based early detection of contamination in tissue cultures of Brown Mustard (*Brassica juncea*) and Orchid (*Dendrobium*) using machine learning, since there is no existing literature specifically addressing the early detection of contamination in Brown Mustard and Orchid tissue cultures. The dataset of 2030 images were acquired after preparation of culture media, embryo culture, and shoot culture from both species. Image pre-processing techniques such as background reduction, noise removal, contrast adjustment, and normalization were applied in Python. Feature extraction was carried out by extracting forty-four color features and fourteen texture features. Model development involved supervised machine learning algorithms such as Support Vector Machines (SVM) and K-Nearest Neighbors (k-NN). A 5-fold cross-validation approach was employed to evaluate the model's robustness and reduce overfitting risks. The SVM model achieved a validation accuracy of 87.4%, corresponding to an error rate of 12.6%, while the k-NN model demonstrated a higher validation accuracy of 98.8%, with an error rate of only 1.2%. The results highlighted that the k-NN model could accurately detect the early contamination in Brown Mustard and Orchid when compared with SVM. As a summary, this research presents an innovative approach to the automated detection of microbial contamination in tissue cultures. The future work aims to integrate advanced imaging techniques, develop comprehensive datasets, and enhance classification models.

Keywords: brown mustard; orchid; contamination; machine learning; image processing

Evaluation of Drought Tolerance and Yield Performance of Tomato (*Solanum lycopersicum* L.) Varieties Released by the Department of Agriculture in Sri Lanka

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Abstract

Increasing drought frequency and water scarcity in Sri Lanka have become major threats to sustainable crop production, particularly in rain-fed systems. Tomato (*Solanum lycopersicum* L.), a high-value but drought-sensitive crop, experiences severe growth and yield reductions under limited water conditions. This study evaluated the drought tolerance and yield performance of 13 tomato varieties released by the Department of Agriculture: KWR, T 245, KC 1, Ravi, Thilina, Tharindu, Rajitha, Rashmi, Maheshi, Lanka Sour, Bathiya, Lanka Cherry, and HORDI Tomato Hybrid, to identify varieties suitable for water-limited environments. The experiment followed a Randomized Complete Block Design with six replicates and three irrigation treatments: (T_1) no water stress, (T_2) high water stress (12 days of stress at three weeks after transplanting followed by seven days of irrigation and another 10 days of stress at 50% flowering), and (T_3) moderate water stress (10 days of water stress at 50% flowering). Growth parameters were measured six weeks after transplanting, and fruit number and economic yield per plant were evaluated. Results showed significant ($p<0.05$) differences among treatments and varieties for all growth and yield parameters. The highest plant height and leaf area were recorded in T_1, while the lowest occurred under T_2. The number of flower clusters and total fruits per plant decreased significantly under water stress, particularly in T_2. The highest economic yields were recorded in the HORDI Tomato Hybrid (T_1-2584 g, T_2-2367.5 g, T_3-2434.5 g) and 'Bathiya' (T_1-2390 g, T_2-2061.5 g, T_3-2320.5 g), while 'Lanka Cherry' (T_1-216 g, T_2-83.5 g, T_3-198.5 g) and 'Lanka Sour' (T_1-442.5 g, T_2-237.5 g, T_3-337.5 g) recorded the lowest yields. Overall, HORDI Tomato Hybrid and Bathiya demonstrated superior drought tolerance and yield stability across treatments, indicating strong potential for adoption in water-limited regions to support climate-resilient tomato production and food security in Sri Lanka.

Keywords: water stress; *Solanum lycopersicum* L.; drought tolerance; yield performance; varietal response

Applied Information Systems, Strategy, Societal Impacts

Evaluating WhatsApp's Usability as a Multi-purpose Tool Using the System Usability Scale (SUS)

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Abstract

This study investigates the usability of WhatsApp as a multi-purpose digital platform supporting personal productivity tasks among postgraduate professionals in Sri Lanka. While WhatsApp is primarily designed for communication, its widespread adoption has led many users to repurpose it for non-conventional uses such as note-taking, file storage, and task management. Using an adapted version of the System Usability Scale, data were collected from 56 participants working in the technology sector. The adapted questionnaire was validated through reliability analysis, with Cronbach's alpha reported at 0.74, indicating acceptable internal consistency. The mean SUS score was 75.09 (SD=15.56), exceeding the industry benchmark of 68 and suggesting high overall usability. Exploratory and inferential statistical analyses, including t-tests, correlation analyses, one-way analysis of variance, and principal component analysis, were conducted to examine usage behaviours, feature preferences, and perceptions of productivity-related affordances. Principal component analysis revealed two dominant factors associated with organisational difficulty and content retrieval challenges. However, this high usability score contrasts with frequent user-reported difficulties in locating saved information, which underscores a critical limitation in WhatsApp's design for personal productivity. These insights contribute to the broader discourse on how everyday communication tools can evolve to better support organisational workflows. Recommendations are provided for developers seeking to enhance productivity features in ubiquitous messaging applications.

Keywords: WhatsApp; system usability scale; personal productivity; postgraduate professionals

Association Between Physical Activity and Physical Fitness in the Information Technology Workforce of Sri Lanka

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Abstract

IT professionals are prone to sedentary lifestyles due to prolonged screen time and limited physical activity (PA). Despite global research on PA among office workers, evidence on Sri Lankan IT professionals in South Asia remains limited. This study examined the association between PA and physical fitness (PF) among Sri Lankan IT professionals to identify emerging health issues. A cross-sectional analytical study was conducted among 210 IT professionals (n=210) using a convenience sampling method. PA was assessed using the International PA Questionnaire-Short Form (IPAQ-SF), while PF was evaluated using the Self-Reported Fitness (SRFit) scale. Descriptive statistics, chi-square tests, one-way ANOVA, Mann-Whitney U, and Spearman's correlation were used to analyze associations between PA, PF, and demographic variables. Results showed 55% of participants (95% CI: 49-61%) were categorized as having low PA (median: 537 MET-min/week, IQR: 240-1200), a higher proportion compared to similar IT populations in South Asia. Prolonged sitting (≥6 hours/day) was reported by 72% of respondents, and limited access to fitness facilities (18%). Males were 3.1times more likely to achieve high PA (χ^2=9.68, p=0.008) and reported greater muscular strength (Mann-Whitney U=7724, p=0.007), reflecting sociocultural barriers for women. A moderate positive correlation linked PA and SRFit scores (ρ=0.40, p<0.001), with diminishing returns at higher PA. Work arrangements (on-site/hybrid/remote) showed borderline significance (p=0.082) in influencing PA patterns. The study concludes that low PA and prolonged sitting are highly prevalent among Sri Lankan IT professionals, and that higher PA levels are moderately associated with better self-reported PF. A key limitation is the use of convenience sampling and self-reported measures, which may reduce accuracy and limit generalizability. The findings highlight the need for tailored workplace interventions, including gender-sensitive programs, ergonomic modifications, and structured activity breaks, to reduce sedentary risks. Future studies should use objective activity measures and longitudinal designs for clearer causal insights.

Keywords: physical activity; physical fitness; sedentary behavior; occupational health; information technology professionals

The Effect of Project Environment on IT Consultant Turnover Intention: A Case Study of Rizing Lanka (Pvt) Ltd

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Abstract

The IT consulting industry is driven by the current dynamic environment, where large and prestigious IT projects are being executed for clients worldwide. This field relies heavily on the stability and expertise of its specialized workforce to successfully deliver significant projects. However, the widespread global challenge of high employee turnover has undermined the organization's quality, performance, and deliverables. This study addresses this critical issue through a case study of Rizing Lanka (Pvt) Ltd, an established IT consulting firm specializing in SAP enterprise solutions, aiming to assess how specific elements of the project environment influence IT consultant turnover intention. The research specifically focuses on four key dimensions of the project environment: team dynamics, project scope, project leadership, and work-related stress. Adopting a positivist research philosophy and a deductive approach, the study conducted a quantitative strategy. Data collection was administered through a structured questionnaire using a five-point Likert Scale, targeting the entire population of 196 SAP Consultants at Rizing Lanka. The collected data were analyzed using IBM SPSS Software. The multiple linear regression was utilized to determine the relationships and predictive strength of the variables. The inferential statistics provided a strong statistically significant relationship between all four project environment factors and turnover intention (R^2=0.836). The regression analysis beta values further denoted that work-related stress (β=0.280) and project leadership (β=0.274) are considered the most significant predictors of increased turnover likelihood. In conclusion, the findings confirm that the project environment, mainly through the focus of team dynamics and project scope are major contributor to turnover intentions of the IT Consultants. The study strongly recommends the need for IT Consulting organizations to prioritize implementing effective internal project leadership, fostering successful team-oriented projects, and establishing comprehensive reward systems, together with greater work flexibility, to mitigate the global challenge of high employee turnover strategically.

Keywords: IT consultants; leadership; project environment; turnover intentions

Prediction Model for Flood-affected Areas in River Basins: A Case Study of the Attanagalu Oya River Basin, Sri Lanka

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Abstract

Sri Lanka is particularly prone to seasonal flooding due to monsoons and periods of heavy rainfall. Gampaha District is one of the most flood-prone regions in Sri Lanka. The main cause of the Gampaha flood is the Attanagalu Oya, which experiences both the southwest monsoon and the northeast monsoon, with annual rainfall ranging from 1400 to 2500 mm. Therefore, the area faces flood hazards every year. Most of the existing flood early warning systems in the country often lack forecast accuracy, creating the need for more adaptive, data-driven solutions. This study presents a comparative analysis of three supervised machine learning models, namely Random Forest (RF), Support Vector Machine (SVM), and Extreme Gradient Boosting (XGBoost), for predicting flood-prone areas in the Attanagalu Oya basin. The key features used in model training include rainfall, water level (m), proximity to the river (km), pre-assigned risk level, and historical flood data from 2016 to 2024 for 102 Grama Niladhari divisions. Daily rainfall was obtained from the Sri Lanka Department of Meteorology, and river water level at the Attanagalu Oya Dunamale gauge (2016–2024 was obtained from the Irrigation Department's hydrology records. Historical flood data from 2016 to 2024 were obtained from the Disaster Management Centre of Gampaha. Raw hydrological data were cleaned and standardized before modelling. Flood event labels were generated by applying threshold criteria to the peak river stage relative to warning levels. The dataset was split into training and validation. 80% of the data was used for training, and 20% was used for validation. The performance of each model was evaluated based on various performance measures, including precision, accuracy, recall, F1-score, confusion matrix, and ROC-AUC. At the end of the study, the XGBoost model achieved the highest overall performance with 0.866 accuracy, 0.67 precision, 0.51 recall, an F1-score of 0.58, and an AUC of 0.89. Random Forest followed with 0.82 accuracy and 0.46 F1-score, while SVM recorded the lowest measurements with 0.51 accuracy and 0.34 F1-score. XGBoost offered the most reliable trade-off between true and false positive rates, making it the preferred model for flood forecasting tasks. In addition, the XGBoost model was integrated into a Python-based interface that can predict flood risk for specific GN divisions, providing a scalable and functional tool for early flood warnings. Future work should focus on incorporating real-time sensor data, expanding spatial features, and generalizing the model to other river basins.

Keywords: Flood prediction; machine learning; Attanagalu Oya; XGBoost

Enhancing Early Detection of Parkinson's Disease through an Optimized Voice-based ML Pipeline

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Abstract

Parkinson's Disease (PD) is a progressive neurodegenerative disease associated with both motor and non-motor symptoms, including tremor, muscle rigidity, and speech impairments. Early detection is necessary as it provides the opportunity for early intervention and improved clinical outcome; however, the traditional diagnostic approach may rely on the appearance of late-stage symptoms. Machine learning (ML) is a potential non-invasive alternative for early PD detection using accessible biomarkers such as voice data. In this paper, we propose a proof-of-concept optimized ML pipeline that incorporates mutual information-based feature selection, class balancing via the synthetic minority oversampling, and hyperparameter tuning through GridSearchCV to enhance the predictive accuracy of early-stage PD detection. The dataset retrieved from the UCI Machine Learning Repository consists of 195 voice recordings alongside 22 features, which are biomedical voice-related attributes. Four classification models: Random Forest, Support Vector Machine, Logistic Regression, and K-Nearest Neighbors were optimized and assessed. The Random Forest classifier outperformed the rest, achieving 95.9% accuracy and a ROC AUC of 98.4%. The results demonstrate that the proposed pipeline significantly improves predictive accuracy and model robustness, thus showing a strong promise for non-invasive PD screening in early and investigative stages in clinical environments.

Keywords: Parkinson's disease; feature selection; hyperparameter tuning; classification

Impact of Versioning and Release Management Strategies on Software Evolution: Development an Integrated Framework

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Abstract

Effective software versioning and release management are fundamental to ensuring the sustainability, quality, and security of modern software systems. As organizations increasingly embrace Agile and DevOps methodologies, the need for a robust and integrated framework that harmonizes versioning strategies, automated release pipelines, and stakeholder communication has become increasingly vital. This research investigates contemporary industry practices by combining a comprehensive literature review with an empirical study involving software professionals from diverse organizations. The findings reveal that while Semantic Versioning and Continuous Integration/Continuous Deployment automation are widely adopted, several persistent challenges continue to hinder effective software evolution. These include managing interdependencies, maintaining backward compatibility, ensuring cohesive coordination across distributed teams, and producing comprehensive and meaningful release documentation. Additionally, many organizations face difficulties embedding security assurance and risk management practices within their release workflows, which affects both reliability and compliance. Drawing upon these insights, this study proposes an integrated framework that aligns technical, organizational, and communication aspects to support scalable, secure, and adaptable software evolution. The framework emphasizes synchronization between versioning strategies and automated delivery pipelines, improved documentation standards, and proactive security integration. By bridging existing gaps between technical implementation and organizational processes, the proposed model aims to empower software teams to deliver high-quality releases efficiently and consistently while adapting to the demands of dynamic and complex development environments.

Keywords: software versioning; release management; software evaluation

A Multimodal-based Mobile Solution for Early Dyslexia Detection: Combining Handwriting, Eye Tracking, and Reading Analysis (MindTrack)

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Abstract

Dyslexia is a common learning difficulty that affects reading, writing, and speaking, often causing academic challenges when undetected early. Conventional diagnosis relies on expert judgment, risking missed subtle signs. This study introduces MindTrack, a mobile system for early dyslexia detection through handwriting, eye movement, and voice recordings, allowing users to submit samples across platforms. The dataset included 150 handwriting samples sourced from GitHub and therapy center, 360 eye-tracking image samples from a Google Research dataset, and 92 recorded reading audio samples, collected from a school and a therapy center. Participants were children aged 6-12 from school and therapy centers, with ethical clearance and parental consent obtained. All datasets were preprocessed for standardization, quality enhancement, and noise removal. Each input type is processed through a dedicated machine learning model, handwriting is analyzed using a convolutional neural network to detect spatial and structural writing patterns, eye movement is examined through a variational autoencoder to identify irregular gaze behaviors, and audio recordings are evaluated using an isolation forest to capture reading fluency irregularities. Model outputs are integrated through logistic regression fusion to produce a final diagnostic outcome, then converted into human-readable feedback through a large language model. Experimental evaluation demonstrated that the handwriting analysis achieved an accuracy of 90.00%, the eye movement analysis reached 81.69% accuracy, and the audio analysis achieved 87.00% accuracy. The fusion approach achieved exceptionally high diagnostic accuracy, though this performance is likely influenced by the very small test set (8 samples), suggesting potential overfitting and should therefore be interpreted as proof-of-concept rather than conclusive clinical accuracy. The integration of these three modalities into a single mobile application offers a novel, scalable, and user-friendly approach to dyslexia screening, with the potential to improve accessibility to early detection for educational institutions, clinicians, and families, thereby enabling timely interventions that support learning outcomes.

Keywords: Dyslexia detection; multimodal learning analytics; handwriting analysis; eye-tracking; speech analysis

Multimodal Detection of Natural and AI-generated Voices using Lip, Eye, and Emotional Voice Analysis

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Abstrac2t

The rapid advancement of AI-generated voice synthesis has raised serious concerns about the authenticity of digital communication and the spread of misinformation. As synthetic speech increasingly mimics human vocal and behavioral patterns, conventional single-modality detection systems are often insufficient for reliable verification. This study presents a tri-modal detection framework that integrates emotional voice cues, lip-movement synchronization, and eye-behavior dynamics to distinguish natural from AI-generated speech. The framework was developed in three phases: unimodal model training on a speaker-disjoint primary dataset, cross-dataset evaluation on unseen voices and synthesis systems, and weighted fusion optimization using grid search. Each modality employed a model suited to its features Long Short-Term Memory networks for sequential audio and lip-motion data, and a Random Forest classifier for eye-tracking behavior. Data preprocessing included temporal alignment and normalization across external datasets to ensure consistency in cross-validation. On the primary dataset, unimodal models achieved near-perfect accuracy, reflecting controlled conditions rather than real-world deployment. External evaluations produced realistic generalization results of 88.0-95.0% across modalities. Weighted fusion of eye, lip, and audio modalities (0.5, 0.3, and 0.2 weights) achieved 97.5% accuracy and superior robustness. Despite its promising performance, the system presents certain limitations, particularly its sensitivity to low-quality video inputs, environmental lighting variations, and synchronization inconsistencies across multimodal data streams. Ethical considerations were rigorously upheld, with explicit participant consent and secure handling of eye-tracking data to ensure privacy and compliance with research ethics standards. The proposed tri-modal approach advances trustworthy AI content verification and has practical implications for digital forensics, media authentication, and misinformation mitigation. Toward real-time deployment, several practical challenges persist, including processing latency, hardware variability, and integration across diverse computing environments. Future research will focus on enhancing computational efficiency, developing lightweight and scalable deployment architectures, and extending multilingual and cross-domain adaptability for live communication and verification platforms.

Keywords: AI-generated speech; tri-modal detection; emotional voice; eye-tracking behavior

Development of a Fall Prevention and Impact Reduction System for Toddlers (Ages 3-5) using AI-driven Airbags

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Abstract

Falls among toddlers aged 3-5 pose significant injury risks to critical areas such as the head and torso, yet most existing fall-prevention systems are designed for adults and fail to address toddlers' unique biomechanics. This study develops a wearable airbag system that uses machine learning (ML) to detect and mitigate forward falls in real time. The system integrates an MPU6050 inertial sensor with an ESP32-S3 microcontroller to continuously track motion and distinguish falls from high-energy activities like running or jumping. A Fall Severity Angle Index (FSAI) is introduced, which adjusts detection thresholds based on each child's height, weight, and movement patterns to reduce false alarms and improve accuracy. A custom dataset was collected from 50 toddlers performing simulated forward falls and routine movements under controlled indoor conditions. Support vector machine and Random Forest (RF) models were trained on this dataset, with RF achieving the best performance at 96% accuracy, 0.97 precision, and 0.95 recall. Upon detecting a fall, the system deploys a CO_2-powered pneumatic airbag through a solenoid valve within approximately 400 ms, providing cushioning for the head and torso while maintaining comfort and mobility. Although results are promising, the dataset's limited size, indoor-only collection, and focus on forward falls constrain real-world generalization. Safety considerations such as CO_2 deployment, accidental inflation, and long-term comfort also require further validation. Nonetheless, this work demonstrates a novel approach to toddler safety by combining adaptive ML-based detection, sensor fusion, and rapid pneumatic response. Future work will expand dataset diversity, validate the FSAI empirically, include multiple fall types, and conduct real-world field trials to strengthen reliability.

Keywords: fall detection; wearable safety device; machine learning; airbag system; toddler safety

A GPS-based Real-time Bus Tracking System for Improving Commuter Experience in Sri Lanka's Public Transportation

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Abstract

Transportation in Sri Lanka largely relies on trains and buses, which are critical for everyday commuting. Although buses and trains are critical modes of transport, passengers deal with uncertainty, long wait times, and frustration from having no real-time status of buses. This research proposes a solution to these issues by introducing and evaluating a mobile application called Roady that improves commuter experience through live bus location and status tracking, fare information, and schedule information. The application system architecture consists of two interfaces, a passenger interface for live bus location and bus route information, and a driver app that provides Global Positioning System (GPS) information to a cloud-based real-time database. The application was built in Android Studio, and the front end is written in Java, while Google Maps is integrated to allow accurate visualization of bus routes. A structured software development methodology was engaged during the development process that was guided by functional and non-functional requirements. The user interface and experience were designed to be simple, accessible and efficient on a variety of devices. Testing during development included unit testing, integration testing, and user acceptance testing, which ensured reliability, responsiveness, and performance of the application. Passengers and drivers provided user feedback to support further refinements for usability and accuracy. The study found that GPS tracking systems in real-time improved on-time behavior of bus service, eased commuter uncertainty, and bolstered confidence in bus service. The project demonstrates the actual value of integrating information and communication technology into public transport systems. By providing accurate, accessible, and real-time information, Roady helps promote sustainable urban mobility in Sri Lanka and promotes greater use of public transport. The study demonstrates the potential for technology to modernize public services, reduce reliance on private vehicles, and support environmentally sustainable transportation planning.

Keywords: bus tracking system; android application; GPS; innovation; public transport; real-time tracking

Impact of Software Evolution on User Retention: Role of Feedback-driven Development in Enhancing User Retention

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Abstract

The sustainability of contemporary software systems is becoming more dependent on the ability of systems to meet mutating user demands and expectations. Feedback-driven development has proved itself to be a critical paradigm to attain such adaptability, with developers being able to elicit user feedback and continuously improve software functionality and user interface. The proposed study will focus on the systematic incorporation of formal feedback systems, with Artificial Intelligence (AI) functionality, in the software development life to improve long-term user retention. Based on recent studies and cross-industry case studies in such domains as Software as a Service (SaaS), fintech, and e-commerce, it covers the procedures and obstacles of gathering, analyzing, and operationalizing user feedback. Moreover, it examines how AI techniques like sentiment analysis, reinforcement learning, and predictive modelling can automate and enhance feedback analysis, allowing adjustments at the interface level to be made dynamically and tailored to the user. The study ends with a cohesive AI-based solution to the ongoing integration of explicit and implicit user feedback into dynamic software systems. The results show that the strategy has a significant potential to decrease churn, increase user satisfaction, and boost the competitiveness of digital products in the long term.

Keywords: feedback-driven development; user retention; software evolution; user experience; predictive analytics

Bridging the Digital Divide: A Case Study on the Influence of Technology Readiness on Digital Enablement Technology Acceptance in a Selected Sri Lankan Apparel Firm's Supply Chain

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Abstract

This study examines the key constructs of technology readiness influencing the adoption of digital transformation tools among supply chain workers in the Sri Lankan apparel industry. As organizations increasingly rely on data-driven decision-making, understanding the determinants of digital tool adoption is crucial for improving operational efficiency and strategic supply chain management. Utilizing a cross-sectional survey design with a positivist research philosophy and deductive methodology, primary data was collected using established, multi-item Likert scales from 315 employees across various stratus of an apparel manufacturing firm. The study employed quantitative techniques, including regression analysis and descriptive statistics, to identify significant technology readiness factors such as infrastructure availability, technology investment, hardware access, software access. The findings provide valuable insights for management, operation, IT, and supply chain departments aiming to facilitate the seamless integration and effective use of digital transformation tools. Additionally, the study contributes to the growing body of knowledge on digital transformation adoption in the Apparel sector and offers practical recommendations for fostering a centric organizational culture. By leveraging established theoretical frameworks, this research presents a structured approach to analyzing adoption determinants. Further the study found that access to software and hardware are the most significant predictors of user acceptance of digital transformation tools in the Sri Lankan apparel industry's supply chain sector. Organizations with strong infrastructure will experience higher adoption rates, whereas those lacking technological infrastructure will face challenges in implementation. Beyond organizational strategy, the findings carry significant weight for policymakers and training institutions concerned with workforce digital literacy and social equity. The findings highlight that successful digital transformation requires technology readiness, investment in IT infrastructure, continuous employee training, and strong managerial advocacy to drive acceptance and long-term engagement with digital tools.

Keywords: apparel industry; digital enablement tools; supply chain; technology readiness

Developer Turnover and Its Impact on Software Familiarity

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Abstract

The present study examines the influence of developer turnover on software familiarity and evolution within both startup and enterprise contexts. Based on a mixed-methods research design, the study combined a quantitative repository mining technique with qualitative research methods (surveys and semi-structured interviews) to integrate the concept of data triangulation. Repository data sourced from GitHub and GitLab were analyzed using metrics such as code churn, bus factor, defect density, and bug-inducing commits. Transcripts from interviews and survey responses were subjected to thematic analysis to uncover recurring patterns related to knowledge retention, onboarding duration, and documentation practices. The techniques that were adopted to investigate the impact of organizational maturity on the relationship between turnover and software quality were the statistical correlation, frequency analysis, and cross-case comparison. Findings revealed that startups experienced turnover rates exceeding 40%, resulting in increased post-turnover code churn and higher defect density. Enterprises were making more effective familiarization, even though they were slower to adopt new developers, using structured onboarding programs, modular architecture, and detailed documentation. The discussion showed that there was a quantified trade-off between the speed of integration and long-term sustainability: startups had focused their desire to produce quickly at the cost of technical debt, and enterprises cared more about knowledge management and resiliency in the long term. The study presents an empirical model that can be used to connect turnover dynamics and software evolution metrics and gives practical advice on reducing the knowledge drain. Strengthened documentation, peer-mentoring initiatives, and modular code ownership were identified as key strategies for preserving software familiarity. Overall, the findings underscore that organizational maturity and process formalization critically determine the extent to which developer turnover impacts software quality, project continuity, and team productivity.

Keywords: developer turnover; software familiarity; knowledge retention; code churn; bus factor

Early Detection of Diabetic Foot Ulcers using AI-powered Image Processing and Chatbot Integration

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Abstract

Diabetic foot ulcers are a critical and debilitating diabetic complication, which often ends in infection and amputation. The existing detection systems mainly rely on slow and subjective clinical judgment; therefore, the current paper presents an intelligent non-invasive mobile-based system that takes advantage of deep learning and Explainable Artificial Intelligence in order to support the timely detection and severity levels of these ulcers. The fundamental detection algorithm uses a Convolutional Neural Network with the specific fine-tuned ResNet-50 architecture, which is used to classify the images. This model was trained on a publicly accessible dataset of about one thousand images, which were processed and properly normalized and denoised. Gradient-Weighted Class Activation Mapping was incorporated to provide graphical support to the choices made by the model to improve clinical trust. Other elements embedded in the overall platform are a symptom-based consultative chatbot and a mobile interface for remote-patient self-monitoring. The model was carefully tested on a ten-fold cross-validation, with the results being solid performance measures on the classification of ulcers: an accuracy of 94.7, a recall of 92.1, and an F1-score of 93.4. Testing the usability of a working prototype demonstrated a high level of interest of patients in engagement, which means that there is a strong possibility of minimizing diagnostic delays and relieving the patient burden on healthcare workers. The work provides a very accurate and sound structure of chronic disease management, and upcoming work will focus on clinical validation in the future in order to overcome the limitations of the current public information.

Keywords: diabetic foot ulcers; image processing; deep learning; convolutional neural networks; artificial intelligence; Grad-CAM

From Vision to Reality: Cross-industry Evidence on Strategic IT Alignment for Sustainable Growth

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Abstract

Strategic IT alignment with organizational vision is the prime driver to agility, efficiency and innovation in modern enterprises. Existing studies mostly address IT-business alignment for industries or geographic regions, leaving limited cross-industry evidence on practical implementation. This research investigates IT alignment in three unique organizations: (1) Innodata Lanka, a digital content services firm employing global operations; (2) CBL, a Sri Lankan conglomerate engaged in food manufacturing; and (3) Sezenta, a startup software solutions firm. All three cases possess a unique operating size, technology landscape, and market positioning. Research follows the qualitative path based on semi-structured interviews with senior executives, managers, and significant stakeholders, complemented by organizational documents. Thematic analysis revealed four enablers of alignment: leadership commitment, cross-functional collaboration, innovation adoption and technological change adaptability. Specific deployments included Innodata Lanka's shift to secure cloud computing, automation of repetitive workflows, and the inclusion of AI and higher-order analytics; CBL's adoption of ERP and GIS platforms, integration of sustainability into processes, and utilization of VR for customer experience; and Sezenta's drive for digital inclusion, development of ethical AI systems, and formation of strategic technology alliances for business growth. Across cases, alignment initiatives struggled against resistance to change, cost pressures and talent deficiencies. These challenges were overcome by strategic IT governance, continuous upskilling and adaptable strategy tuning. Comparative analysis with existing global literature justified alignment's role in improving operational performance, creating innovation and maintaining competitive advantage. This research provides empirical evidence that well-aligned IT is a primary enabler of organizational vision realization and long-term achievement. It introduces cross-industry knowledge of best practices for alignment with consideration of organizational culture, technological capabilities, and market context. Results offer actionable suggestions to business leaders, policymakers, and practitioners who seek to mainstream IT alignment as part of strategic planning for sustainable development.

Keywords: IT alignment; organizational vision; strategic integration; IT strategy; IT governance

Conceptual Framework on Integrating Visual Literacy into Instructional Design and Technology

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Abstract

In the contemporary digital age, where learners are constantly exposed to visual imagery, there is a pressing need to integrate visual literacy effectively into higher education instructional materials. Despite this pressing demand, visual literacy remains underemphasized, highlighting the need for deliberate efforts to integrate it into teaching practices and learning resources. Despite its growing importance, visual literacy remains insufficiently integrated within instructional design and educational technology, particularly in higher education. The study commenced with a comprehensive literature review, followed by the extraction of existing frameworks related to visual literacy pedagogical studies: Association of College and Research Libraries framework, Metaliteracy, Multimodal pedagogy, Design Based Learning, and Universal Design for Learning. Subsequently, the visual literacy literature was systematically categorized into thematic categories: conceptual and review papers on theoretical perspectives, integration in higher education instructional design and pedagogical approaches, assessment and measurements, blending with technology and multimedia learning, and teacher training and professional development. The limitations of current practices were identified through a critical review of the literature and focus group discussions conducted to capture contextual needs. The main limitations identified through the focus group discussions are insufficient attention to the diverse needs of learners, particularly those with varying cognitive abilities, learners with disabilities, individuals in low-resource environments, and the need for discipline-specific approaches. Moreover, when mapping visual literacy frameworks and literature, the Cognitive Theory of Multimedia Learning was integrated as the theoretical foundation for developing the conceptual framework. Eventually, the Adaptive Visual Literacy Framework was proposed to overcome the identified limitations and refined through the alignment with the Cognitive Theory of Multimedia Learning. Thus, this paper presents a comprehensive conceptual framework for embedding visual literacy into instructional design practices in educational landscapes with diverse learners and resources.

Keywords: visual literacy; instructional design and technology; visual cognition

sEMG-based Gesture Recognition Systems: A Comprehensive Analysis of Databases and Sensing Technologies

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Abstract

Surface electromyography (sEMG) serves as a critical technology for muscle signal acquisition across multiple domains, including neurodegenerative disease detection, human-computer interaction, rehabilitation, sign language recognition, and prosthetic control. This comprehensive review systematically examines three fundamental components of sEMG-based systems: (1) fine motor task applications in sEMG research, (2) available sEMG databases, and (3) signal acquisition devices. The systematic literature review encompassed publications from 2000-2025, with studies categorized into fine motor tasks, followed by further analysis of fine motor tasks into gesture-based and handwriting-based research. The analysis reveals significant research gaps in sEMG applications. While the majority of studies focus on gesture recognition using commercial devices such as Otto Bock, Delsys Trigno, Cometa electrodes, and Myo Armband, handwriting character recognition remains critically underexplored. Most concerning is the complete absence of research on Sinhala character recognition, despite the potential for distinct sEMG patterns due to the script's curved and complex morphology compared to linear English characters. Database analysis identified Ninapro DB-1 through DB-5 as predominantly gesture-focused, with only a single database dedicated to handwriting tasks found within the reviewed timeframe. Furthermore, open-source acquisition devices like OpenBCI platforms received minimal research attention, with no evidence of their application in handwriting recognition studies. These findings highlight critical opportunities for advancing inclusive sEMG research: developing specialized databases for non-Latin scripts, particularly Sinhala characters, systematically evaluating open-source devices for accessibility and cost-effectiveness, and expanding sEMG applications beyond traditional gesture recognition to encompass diverse writing systems and multilingual contexts.

Keywords: surface electromyography; sEMG databases; signal acquisition devices; human computer interaction

Artificial Intelligence and Data Science

Validation and Application of a Financial Literacy Scale for Young Adults in Sri Lanka

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Abstract

Financial literacy has become an essential survival skill for young adults in Sri Lanka, where accelerated digital financial service adoption has created a growing gap between technological access and financial education. This study addresses this critical need by adapting and validating the OECD/INFE financial literacy questionnaire for the Sri Lankan context. Using a sample of 56 respondents aged 18-30, we conducted comprehensive psychometric testing to establish the instrument's reliability and validity. Initial analysis revealed low internal consistency (Cronbach's α=0.19), which improved significantly to α=0.41 after strategic item reversal, demonstrating the measure's responsiveness to optimization. Exploratory Factor Analysis (EFA) with varimax rotation identified two robust latent dimensions: (1) financial planning orientation (eigenvalue=2.1, explaining 38% variance), capturing saving discipline and budgeting practices with high mean scores (M=4.3, SD=0.7), and (2) financial comprehension (eigenvalue=1.7, explaining 31% variance), reflecting understanding of financial products that showed concerningly low proficiency (M=2.9, SD=1.1). The KMO measure of sampling adequacy was 0.41 with Bartlett's test of sphericity significant at p=0.030, indicating marginal but acceptable factorability. Results reveal a troubling disparity between respondents' positive financial intentions and their actual comprehension of fundamental concepts, particularly in calculating interest rates (only 22% correct responses) and evaluating loan terms (17% accuracy). This "intention-comprehension gap" suggests that while young Sri Lankans demonstrate awareness of financial planning importance, they lack practical skills for sound decision-making. The study makes three key contributions: (1) a validated, culturally-adapted measurement tool for financial literacy assessment, (2) empirical evidence of specific knowledge gaps requiring educational intervention, and (3) methodological insights for questionnaire adaptation in developing economies. These findings enable policymakers to design targeted financial education programs addressing both technical knowledge and practical application skills, with particular urgency for digital finance contexts.

Keywords: financial literacy; scale validation; youth; exploratory factor analysis

Vision-based AI System for Realtime Motion Evaluation and Feedback in Fitness Training

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Abstract

As digital health technologies become increasingly integrated into everyday life, maintaining safe and effective workout routines remains a challenge for many individuals due to the absence of real-time feedback, personalized coaching, and reliable performance evaluation. Existing fitness applications and wearables primarily focus on activity tracking rather than posture correction or injury prevention, creating a gap in intelligent, accessible fitness guidance. This research presents the design and implementation of an intelligent bot-based system that evaluates gym workouts and delivers real-time feedback to users. The system integrates two interdisciplinary areas, computer vision and reinforcement learning to capture, analyze, and assess human motion. Using OpenPose, the system performs pose estimation through a standard webcam, detecting 17 skeletal key points per frame. Reinforcement learning (Q-learning) is employed to compare live joint angles with coach-recorded reference movements, enabling adaptive evaluation and feedback generation. Real-time graphical feedback is displayed by highlighting incorrect joints in red on the on-screen skeletal model, while verbal cues such as “Keep going” or “Let’s try that again” enhance motivation and mimic a personal trainer’s guidance. The system was tested with ten volunteer participants, each repeating a coach-led exercise three times. Results showed significant improvement in posture accuracy and performance efficiency across sessions. Statistical analysis indicated that male participants reported higher difficulty levels than females ($p=0.022$), while age did not significantly affect perceived difficulty ($p=0.213$). These findings demonstrate that the proposed system effectively supports users in improving exercise form and motivation using accessible, low-cost technology, highlighting its potential applications in fitness training, rehabilitation, and home-based physical therapy.

Keywords: intelligent exercise system; motion capture; reinforcement learning; Openpose; computer vision

A Clinical Evaluation of Deep Learning-based Detection of Intertrochanteric Femoral Fractures in X-ray Images

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Abstract

Intertrochanteric femoral fractures are a serious condition common among the elderly because they are associated with high morbidity and mortality. Precise identification is crucial for prompt treatment, but it can be quite difficult when interpreting X-rays individually due to anatomical complexity and variability. In this study, deep learning models are used to optimize the binary classification of intertrochanteric femoral fractures within X-ray images. An X-ray dataset of about 1,000 images from hospital PACS was used, including both fracture and non-fracture cases. A convolutional neural network (CNN), comprising ResNet50, ResNet101, InceptionV3, and a custom CNN, was fine-tuned using preprocessing and augmentation to manage clinical variability. The models' performance was evaluated based on accuracy, precision, and sensitivity, with ResNet101 achieving the highest results (accuracy: 0.8000, precision: 0.8179). Statistical validation was conducted using confidence intervals (90, 95, and 99%) CI for fracture and non-fracture detection. The improved diagnostic accuracy has significant clinical implications, enabling faster diagnoses and better outcomes in time-sensitive environments. This study demonstrates the promising potential of deep learning in addressing diagnostic challenges in the identification of intertrochanteric femoral fractures, supporting its integration into clinical practice.

Keywords: intertrochanteric femoral fractures; deep learning; X-ray imaging; fracture detection; statistical analysis

AI-driven Framework for Developing Disaster Awareness Chatbots: A Literature Review and Stakeholder-centric Approach for Climate Resilience in Sri Lanka

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Abstract

The socio-spatial landscape of Sri Lanka is increasingly imperiled by floods and landslides driven by climate change. In the aftermath of the tsunami, enhancements of the disaster risk reduction (DRR) have been implemented in institutional responses. Nonetheless, the awareness within the community, the planning for disaster mitigation, and the responses at the community level continue to be stagnant, disjointed, and imposed from above. This study explores the potential of AI-driven chatbots to address deficiencies in disaster risk communication. The specific objectives are (1) to synthesize global evidence from chatbot-based disaster management systems, and (2) to integrate stakeholder insights to design a participatory and predictive framework for risk communication and mitigation. The literature review adopted PRISMA guidelines and examined studies from Scopus and Web of Science databases up to January 2025. Fifty-five chatbot applications were analyzed in relation to disaster phases, technology types, and user participation levels. Findings were triangulated with two rounds of expert consultations involving NBRO, UDA, and ICTA stakeholders. A structured content analysis was conducted using predefined indicators of functionality, interactivity, and user participation to assess each chatbot's contribution to disaster management. The findings demonstrate a scarcity of global pre-disaster education and participatory mitigation planning. The subsequent phase of stakeholder engagement has reinforced the necessity for tailored awareness strategies aimed at distinct user groups, including developers, planners, investors, and the general populace, concerning the different phases of a disaster-before, during, and after the event. Therefore, the proposed framework combines a rule-based and AI-driven hybrid architecture enhanced by predictive modeling for hazard forecasting. It employs bi-directional context awareness-linking spatial, linguistic, and situational data-to adapt responses dynamically during disaster phases. The resulting framework establishes measurable parameters for chatbot performance-context relevance, user engagement, and linguistic adaptability-forming the foundation for prototype evaluation in Sri Lanka's DRR context. This initiative emphasizes the necessity for a transformation in disaster communication strategies, advocating for a transition from reactive announcements to proactive and insightful engagement frameworks.

Keywords: disaster risk reduction; AI chatbots; stakeholder engagement; climate resilience; data science

AI-driven Voice-based Autism Spectrum Analysis in Sinhala Speaking Children Aged 2-10

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Abstract

Autism Spectrum Disorder (ASD) prevalence is rising in Sri Lanka, underscoring the need for early diagnostic tools tailored for the Sinhala speaking children. This study presents an AI-driven method for quantifying ASD risk from vocal features in children aged 2-10. Common ASD-related speech traits were initially identified through a comprehensive literature review and expert consultations. These traits were systematically categorized into three main groups: temporal (e.g., silence duration, utterance duration, speech rate), behavioral (e.g., repetitive phrases, monotone voice), and acoustic (e.g., Mel-Frequency Cepstral Coefficients (MFCCs), pitch, energy, jitter). Based on these categories, a Sinhala language questionnaire comprising 40 age stratified questions was developed and approved by relevant authorities to naturally elicit speech patterns relevant to diagnosis. Data collection was conducted in school and home environments, using a conversational and child friendly approach to capture authentic speech. Audio preprocessing included resampling to 16 kHz, amplitude normalization, voice activity detection to remove silence and noise, transcription of Sinhala speech, Romanization, and segmentation into meaningful utterances. A convolutional autoencoder was then trained with 360 preprocessed audio clips to reconstruct speech features, achieving a mean squared error of 0.035, mean absolute error of 0.133, and overall accuracy of 89%. Reconstruction errors in MFCC coefficients and prosodic patterns were analyzed to detect deviations from typical speech, enabling identification of children at risk of autism. The results support the use of AI-guided, age-stratified speech evaluation as a supplementary method for early, culturally appropriate ASD screening in resource-limited Sinhala-speaking contexts.

Keywords: autism spectrum disorder; convolutional autoencoder; Sinhala language; speech feature extraction

Machine Learning-based Rainfall Prediction Model using Satellite Product Data for the Eastern Province of Sri Lanka

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Abstract

Accurate rainfall data at specific locations is essential for hydrological studies, and having an optimal number of rain gauges ensures the most precise measurements across the area being studied. According to the Meteorological Department of Sri Lanka, there are only four rain gauges available in the Eastern Province of Sri Lanka, which is insufficient to cover the entire province. Therefore, this study was designed to develop a rainfall prediction model and conduct trend analysis for the Eastern Province using satellite-derived rainfall data. Multiple satellite products PERSIANN, PERSIANN-CDR, PERSIANN-CCS, and TRMM 3B42 were evaluated by comparing them against ground-based rain gauge data. Pearson correlation analysis indicated that PERSIANN-CDR had the highest agreement with ground-truth data and was therefore selected for modeling. The rainfall prediction model was developed in Python and tested across four locations: Batticaloa, Trincomalee, Irakkamam, and Kantalai Tank. Three machine learning models Linear Regression, Support Vector Regression, and Random Forest were developed using PERSIANN-CDR data and validated using rain gauge observations. Among these, the Random Forest model yielded the best performance (R^2=0.64, RMSE=6.84 mm, NSE=0.63). Validation results indicate that the model demonstrates moderate accuracy and potential for improving rainfall estimation in under-gauged areas. Future improvements will include additional climatic parameters such as humidity, elevation, temperature, and wind speed to enhance model precision.

Keywords: rainfall prediction; satellite data; machine learning; PERSIANN-CDR

Advanced Object Recognition and Pointing Assistance Device for the Visually Impaired: Directional and Space Guidance for Multiple Objects in Dynamic Environments, under Real-time Feedback

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Abstract

This research presents the development of an affordable and intelligent assistive device designed to support visually impaired individuals by enabling real-time object recognition, spatial guidance, and voice-based interaction. The system integrates the YOLOv8 object detection model with a custom depth estimation framework and voice interfaces powered by offline speech-to-text (Vosk) and text-to-speech (pyttsx3, Google TTS) technologies. Built on the Raspberry Pi platform, the device is capable of detecting and locating multiple objects within dynamic environments and communicating their relative positions to the user through auditory feedback. It also features an interactive voice command system, allowing hands-free object searching, and supports offline operation for core functionalities. The object detection system achieved a mean average precision (mAP at 0.5) of 0.703, while the custom depth estimation model demonstrated fast load times (as low as 13.77 ms) and effective spatial prediction, enabling real-time directional and distance-based guidance. Voice interaction was responsive and fully functional offline, with a processing time of approximately 0.26 seconds. Users can personalize the system by adding new objects to the recognition database without retraining the entire model. Furthermore, an optional feature allows integration with a multimodal Large Language Model when internet access is available, enabling rich scene descriptions, printed text reading, and currency recognition. This research contributes a scalable, user-centered solution to assistive technology for the visually impaired, offering a practical alternative to high-cost commercial systems that often depend on continuous internet connectivity and lack spatial feedback capabilities.

Keywords: assistive technology; object recognition; custom depth model; visually impaired

Developing a Robust Model for Sinhala Handwritten Sentence Recognition using CNNs and RNNs

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Abstract

Recognition of handwritten text in the Sinhala language remains a complex challenge due to the script's rounded shapes, compound structures, overlapping strokes, and scarcity of large, high-quality datasets. This study presents a deep learning-based approach for Sinhala handwritten sentence recognition that combines spatial feature extraction and sequence modeling in a hybrid architecture. A Convolutional Neural Network (CNN) was designed to recognize 454 classes of Sinhala characters. Concurrently, sentence-level error correction and refinement were conducted using a Recurrent Neural Network (RNN) implemented within a sequence-to-sequence framework. Publicly available Sinhala character and word datasets were used for the experiment, and those datasets consisted of over 100,000 character samples and 102,000 words. The preprocessing pipeline was integrated with Otsu thresholding, morphological dilation, and vertical projection histograms for efficient word and character segmentation. Data augmentation techniques were employed to improve model robustness against handwriting style variability and illumination. The CNN achieved 99.95% training accuracy and 96.97% validation accuracy in character recognition, and the RNN achieved 94.83% training accuracy in word correction. The overall recognition system performed with an accuracy of 70-80% at the sentence level for unseen test data. The model was implemented in real time through a mobile Android application and web interface, enabling users to provide handwritten Sinhala sentences and receive digitized Unicode or PDF outputs in an instant. The study introduces an effective end-to-end Sinhala handwritten sentence recognition system and its real-world implementation, enabling applications in education, cultural preservation, and document digitization. The study sets a strong foundation for the establishment of recognition systems for low-resource scripts in the future and offers a benchmark dataset for future studies in the area.

Keywords: Sinhala handwriting recognition; convolutional neural networks; recurrent neural networks; optical character recognition; deep learning

A Deep Learning Approach for Real-time Sinhala Air-writing Character Recognition using CNNs and RNNs

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Abstract

Recently, deep learning technologies have significantly advanced human–computer interaction with applications in various sectors such as assistive technology, education, virtual reality, and interactive media. In this context, real-time gesture recognition systems play an important role in enabling intelligent and natural interactions, especially for Sinhala, a non-Latin language, which presents unique challenges in the form of complex curved shapes and orthographic marks. The primary objective of this study is to create a robust and effective system for recognizing Sinhala air-writing characters in real time from finger-drawn gestures, incorporating both spatial and temporal data by utilizing the CNN and LSTM/GRU frameworks. In the present research, the laptop's built-in web cameras were utilized to record fingertip motion considering availability and financial constraints. Data were gathered from a heterogeneous group of writers with different velocities and writing styles, creating a dataset of 10,000 video samples of eight base letters of Sinhala and two widely used diacritics. Computational processing employed OpenCV and MediaPipe for consistent frame extraction and fingertip tracking. A two-model strategy was followed: CNN-LSTM model for detection of base letters and a CNN-GRU model for the detection of diacritics. These models were integrated into a real-time pipeline, offering immediate visual feedback. The combined strategy resulted in tremendous improvement, reaching 98% base letter validation accuracy and a perfect diacritic recognition accuracy of 100%. Hence, the findings offer some critical implications for both theory and practice. Theoretically, these results reinforce the view that a dual-model approach is appropriate to fuse the spatial and temporal aspects of gesture recognition in complex scripts. Practically, the system developed so far also stands independent of any typical hardware device, enabling widespread usage in educational and assistive technology contexts and enhancing inclusive digital interaction for Sinhala language users.

Keywords: Sinhala script recognition; air-writing gesture recognition; deep learning; CNN-LSTM; CNN-GRU

TransUNet-based Hybrid CNN-transformer Approach for Accurate Breast Cancer Ultrasound Segmentation

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Abstract

Breast cancer is one of the major causes of death among women all over the world, and it must be diagnosed at an early stage to be cured. Ultrasound is a common and safe imaging method; however, manual interpretation of such images can consume a lot of time and is prone to human error. This study introduces a hybrid deep learning model based on the TransUNet architecture, which combines convolutional neural networks (CNNs) for local feature extraction and transformer encoders for capturing long-range information. The aim is to appropriately segment breast cancer regions in images captured using ultrasound. The publicly available breast ultrasound images dataset, comprising 780 images with expert masks annotated, was utilized. Images within the dataset were resized to 224×224 pixels, and to further enhance the model, additional augmentation methods were employed, including flipping, rotation, and brightness adjustments. The dataset was split into three sets: training (72%), validation (8%), and test (20%) sets. The model was trained for more than 50 epochs using a combination of dice loss and binary cross-entropy loss to enhance pixel accuracy and boundary overlap. The proposed model achieved a dice score of 0.6836 and an intersection over union of 0.5411 on the test dataset, demonstrating very good segmentation performance, particularly given the challenges of ultrasound images. This study focuses on ultrasound images, unlike other studies using mammography. The model outperformed U-Net and U-Net++ 5-8% in dice score. For normal (non-tumor) images, the model usually predicted empty masks, so false positives are low. TransUNet was chosen because it combines a CNN for local details and a Transformer for global context, which is good for ultrasound images. Future work includes improved augmentations, enhanced attention mechanisms, and providing clearer model interpretability to support clinical decision-making. This solution can help radiologists detect breast cancer earlier, especially in areas with limited specialists.

Keywords: breast cancer; deep learning; segmentation; TransUNet; ultrasound imaging

A CGRU Chord Model for Real-Time Guitar Chord Recognition and Next Chord Prediction

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Abstract

This study presents the CGRU Chord Model, a hybrid deep learning framework that combines Convolutional Neural Networks (CNNs) and Gated Recurrent Units (GRUs) with an attention mechanism for real-time guitar chord recognition and next-chord prediction. The model addresses key challenges in Music Information Retrieval (MIR), including polyphonic interference, temporal dependency modeling, and low-latency performance in live environments. The Guitar Chords v3 dataset, containing 1,760 samples across eight chord classes, was preprocessed using Mel-Frequency Cepstral Coefficients (MFCCs) for spectral feature extraction. The dataset was divided into 70% training, 20% validation, and 10% testing sets, with data augmentation (pitch shifting and time stretching) applied to improve generalization. The hybrid CNN–GRU architecture was chosen for its capability to capture both local spectral and sequential harmonic features. Hyperparameter tuning (learning rate 0.001, batch size 32, dropout 0.3) yielded a peak validation accuracy of 86%, surpassing LSTM-based baselines by 5.7%. The model achieved 68.9% accuracy for next-chord prediction and maintained a real-time processing latency of 25 ms per frame. Comparative analysis shows a 12–18% error reduction compared to standalone CNN and GRU models, with robust performance under noisy conditions (79% accuracy at SNR<20 dB). Although the dataset size limits exposure to rare chord variations, future work will extend the dataset to improve generalization. The proposed CGRU model demonstrates strong potential for integration into music education, live performance, and AI-assisted composition, offering a unified, low-latency framework for both recognition and prediction tasks.

Keywords: deep learning; real-time chord recognition; next-chord prediction; music information retrieval; attention mechanism

Machine Learning-driven Prediction of Non-communicable Diseases using Anthropometric Data

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Abstract

This paper examines how machine learning can be used to forecast non-communicable diseases (NCDs), including heart disease, diabetes, and cancer, and explores how their prevalence is largely due to obesity. Based on a sample of anthropometric measurements from adults (Jaffna Teaching Hospital and Sabaragamuwa University of Sri Lanka), excluding children and pregnant women, the study uses ten variables: age, weight, height, gender, body fat mass, total body water, body fat percentage, body mass index, visceral fat area, and waist-to-hip ratio. The most significant characteristic turned out to be the visceral fat area. Machine learning algorithms were employed in binary classification: Random Forest, Extreme Gradient Boost (XGBoost), Artificial Neural Networks, Decision Tree, AdaBoost, Logistic Regression, CatBoost, and Support Vector Machine. The models achieved accuracy rates above 85%, with Random Forest reaching the highest at 98.90%, and outputs indicating Yes (NCD patient) or No. The study utilizes data mining to facilitate knowledge discovery in healthcare systems, which could be beneficial for early detection and enhancing patient well-being through a knowledge discovery in databases approach.

Keywords: obesity; machine learning; non-communicable diseases; prediction; binary classification

sGenre Classification of Sinhala Songs using Machine Learning Based on Audio Features

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Abstract

With the growth of digital music platforms, automated genre classification has become an important tool for music recommendation systems, digital archiving, and artist promotion. While machine learning based classification has been widely applied to Western and Indian music, Sinhala music remains underexplored due to the absence of structured datasets, the unique fusion of Eastern and Western elements, and the prevalence of multi-genre characteristics that challenge conventional classification models. This study presents a systematic approach to classify Sinhala songs across five genres: Pop, Rock, Hip Hop, Classical, and Folk, using only audio features. A dataset of 500 Sinhala songs was manually curated and preprocessed, then segmented into uniform audio clips. Key timbral, spectral, temporal, and harmonic features, including Mel Frequency Cepstral Coefficients (MFCCs), spectral centroid, zero crossing rate, chroma STFT, and root mean square energy, were extracted using the LibROSA library. Four baseline machine learning models, namely Random Forest, Support Vector Machine, k Nearest Neighbors, and Multilayer Perceptron, were developed and evaluated using accuracy, precision, recall, and F1 score. The Soft Voting Ensemble model achieved the highest performance with an accuracy of 81.93%, surpassing the performance of all individual models. An experimental stacked meta-model approach yielded significantly lower accuracy, emphasizing the need for diverse and well-calibrated base models. The findings demonstrate that combining culturally relevant audio features with ensemble learning techniques can effectively classify Sinhala songs by genre, supporting the advancement of AI-driven music applications and contributing to the preservation of Sri Lanka's musical heritage.

Keywords: genre classification; machine learning; audio feature extraction; soft voting ensemble

GASP: A Model for Optimizing Urban Green Space Requirements using Machine Learning

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Abstract

Rapid urban growth across South Asia has intensified air pollution and reduced urban greenery, creating urgent challenges for environmental planning, especially in countries such as Sri Lanka where monitoring networks remain limited. This study presents a machine learning-based framework designed to classify urban environments and test the potential of vegetation expansion as a strategy to reduce fine particulate matter pollution. The analysis used 2024 data from 2,857 cities, combining measurements of air quality based on fine particulate matter with a diameter smaller than 2.5 micrometers, vegetation index values, and population density. An unsupervised learning approach, integrating an autoencoder with k-means clustering, revealed three distinct urban categories: green low-risk, transitional urban, and high-risk urban core. A supervised random forest model, with a predictive accuracy of 0.69, was then applied to simulate increases in vegetation index values from 0.10 to 0.80 and measure the resulting changes in fine particulate matter levels. The results show a clear divide in the effectiveness of greening as a pollution-reduction strategy. In the Green Low-Risk category, all cities reached the United States Environmental Protection Agency's acceptable air quality threshold of 100 on the fine particulate matter index following vegetation-based simulation recommendations. In the transitional urban group, 35 percent reached compliance after moderate vegetation increases, while only 1 percent of high-risk urban core cities achieved the target even at the highest simulated vegetation levels. Limited improvements in high-risk areas were linked to dominant pollution sources such as heavy industry and dense traffic, which vegetation alone could not counteract. These findings underline that while urban greening can deliver substantial air-quality gains in low- and mid-risk cities, severely polluted zones require integrated interventions combining green space expansion with targeted emission controls. The proposed framework offers a scalable, data-driven tool for guiding city-specific environmental strategies across South Asia and beyond.

Keywords: urban air quality; vegetation index; clustering analysis; sustainable city planning; environmental machine learning

Explainable AI Methods in Hybrid Deepfake Face Detection Models

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Abstract

The recent advances in deepfake generation have increased the fear of how authentic the media and the internet security are. Hybrid deepfake face detection models fusing both spatial and temporal information through deep learning technologies can reach high accuracy, although human users do not find them easy to interpret by limiting their adoption in sensitive, real-world applications. Unlike previous approaches, which typically address either performance or explainability or sometimes one of the two, ours explicitly explores their interplay. In here we are methodically considering the integration of explainable artificial intelligence (XAI) techniques into hybrid deepfake face detection systems. We implemented and trained two hybrid deepfake detectors, including CNN-LSTM and vision transformer-CNN on the FaceForensics++ benchmark dataset, yielding state-of-the-art detection accuracies of 98.2% and 98.7%, respectively, significantly outperforming baseline single-modality models. Afterward, three XAI methods named LIME, SHAP, and Grad-CAM were used on all models to obtain explanations of their spatial and temporal reasoning. The objectives of our research were the following (1) to compare the detection accuracy and the explanations quality of model-XAI combinations, (2) to examine the trade-offs between interpretability and performance, and (3) to determine the best suited approach to implement in practice. The results show that while the hybrid models all performed very well on detection, the performance of the XAI methods varied widely. SHAP generated the highest stability scores at 0.92, while Grad-CAM achieved higher faithfulness metrics. Our quantitative examination hence provides empirical evidence on the criticality of choosing an appropriate XAI method. The combination of Vision Transformer-CNN and SHAP performs most robustly and reliably on these models tested. This paper filled the gap in trustworthy AI for digital forensics by providing an important, systematic framework for evaluating explainability. Future work will extend to qualitative user studies focused on assessing the perceived interpretability of these explanations.

Keywords: deepfake; deepfake face detection; explainability; explainable artificial intelligence; hybrid models; interpretability

Enhanced Stroke Risk Assessment using T1-weighted Magnetic Resonance Imaging and Deep Learning

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Abstract

Stroke ranks as a leading global cause of mortality and disability, underscoring the critical need for early detection and precise risk prediction to enhance patient outcomes. T1-weighted Magnetic Resonance Imaging (MRI) serves as a vital tool for visualizing cerebral structures and identifying stroke-related abnormalities. Yet existing analysis methods are constrained by single-task models, limited interpretability, and inadequate patient-level data management, which can lead to data leakage and reduced generalizability. This study addresses these limitations by developing a hybrid deep learning framework that leverages T1-weighted MRI scans for enhanced stroke risk assessment, combining binary classification of stroke likelihood with similarity regression to post-stroke patterns. The research utilized open-access datasets from OpenNeuro, comprising 81 healthy T1-weighted MRI scans and 70 stroke-related scans. Preprocessing involved extracting 25 central axial slices per 3D volume, normalizing intensities to [0,1], resizing to 224x224 pixels, and organizing by patient ID to ensure integrity. Features were extracted using a modified ResNet18 model with selective transfer learning, followed by patient-level stratified splitting and five-fold cross-validation to prevent leakage. A dual-task hybrid model was trained to optimize shared layers for simultaneous classification and regression, incorporating AdamW optimization, dropout, and early stopping. Cross-validation results indicated reliable classification performance (accuracy = 78%, AUC = 0.82), a balanced trade-off between precision and recall. The regression module effectively captured similarity-based risk levels with low prediction errors, revealing clear distinctions between stroke progression stages. This hybrid approach advances stroke risk prediction by providing continuous, interpretable assessments beyond binary outputs, potentially aiding early intervention and clinical decision-making for prevention. These findings highlight the value of dual-task learning and robust data handling in neuroimaging, while future integration of clinical factors such as age, hypertension, and comorbidities is recommended to further enhance model accuracy and real-world applicability, ultimately contributing to reduced stroke burden through personalized prevention strategies.

Keywords: stroke risk prediction; T1-weighted MRI; deep learning; multi-task learning; neuroimaging

An Explainable Machine Learning Framework for Personalized Stroke Risk Prediction

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Abstract

Since stroke is one of the world's leading causes of death and permanent disability, prevention and efficient clinical management depend on early and accurate risk prediction. The lack of trust quantification and poor interpretability of machine learning models based on clinical and demographic data limit their use in healthcare, despite their potential. Many current models function as "black boxes", offering few patient-specific justifications or assurance metrics, which undermines clinician confidence and usefulness. This study develops a personalized stroke risk prediction system integrating explainable AI to address these challenges. Due to the absence of publicly available Sri Lankan stroke datasets, the Kaggle dataset of 5,110 patient records was used for model development and validation. The dataset contains standard clinical and demographic features. The data preprocessing procedure included feature encoding and missing value imputation. XGBoost with imbalance handling and Randomized Search CV tuning trained the model. SHAP for global importance and LIME for local interpretation provided consistent, complementary patient-specific explanations. A real-time interactive interface that displays risk probabilities and patient-specific explanatory insights is incorporated into the system. The class-weighted XGBoost achieved comparatively high PR-AUC and F1-scores, indicating that it effectively addressed class imbalance. Such a model, designed to handle imbalanced data, can be valuable for the early identification of high-risk individuals, even when the dataset's stroke prevalence is as low as 4.87%. The model provided more detailed and clinically relevant personalized assessments by shifting from binary classification to probability-based risk levels (low, moderate, and high). SHAP and LIME ensured transparency by disclosing the critical factors affecting each patient's risk, allowing for customized preventative measures. This work bridges machine learning and clinical practice by combining explainability and usability, promoting reliable AI adoption in stroke prevention, and supporting well-informed decision-making, while acknowledging that using Kaggle datasets may limit generalizability to the Sri Lankan population.

Keywords: stroke risk prediction; explainable AI; clinical interpretability; patient-specific explanation

Automated Slum Detection from High-resolution Satellite Imagery: A Deep U-net Approach with ResNet34 Encoder

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Abstract

Slum detection from satellite imagery is crucial for aiding urban planning, policy-making, and humanitarian efforts to improve housing and living conditions. Unplanned and rapid urbanization has resulted in the spread of informal settlements that are difficult to map with traditional survey techniques. This study presents a deep learning–based binary segmentation model derived from the U-net architecture for delineating slum areas in very-high-resolution remote sensing imagery. The proposed model utilizes a U-net framework with a ResNet34 encoder pretrained on ImageNet for effective extraction of hierarchical spatial features. The encoder–decoder structure, enhanced with skip connections, preserves fine spatial details while integrating deep contextual information across multiple scales. A total of 8,910 tiles (80% training, 20% testing) from the manually annotated high-resolution satellite image dataset of Mumbai (Pleiades-1A, 0.5 m spatial resolution) were used. Slum and non-slum regions were manually labeled based on visual cues such as roof texture, density, and layout. Preprocessing included tile normalization, data augmentation, and contrast adjustment to improve generalization. The model achieved an IoU of 0.848 and F1-score of 0.884, correctly classifying 99.1% non-slum and 97.2% slum pixels. The results, supported by visual overlays of predicted masks on test images, demonstrate the model's robustness in segmenting informal settlements. The proposed approach offers a scalable and transferable framework for urban planners to efficiently identify and monitor slum regions.

Keywords: satellite imagery; slum detection; remote sensing; urban planning

Artificial Intelligence for EEG-based Meditation Classification: A Systematic Review of Machine Learning and Deep Learning Approaches

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Abstract

Mental stress is widely acknowledged as a significant contributor to psychological and physiological disorders, prompting considerable interest in effective therapeutic interventions. Among these, meditation has emerged as a recognized approach for stress reduction and mental well-being. In parallel, the development of brain-computer interaction technologies has created a demand for reliable methods to identify meditation states and traits using electroencephalogram (EEG) signals. In recent years, artificial intelligence (AI), particularly machine learning (ML) and deep learning (DL), has been increasingly applied to this domain. This systematic review, conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses guidelines, provides a critical synthesis of current research on automated meditation recognition using EEG. Relevant studies were retrieved from Web of Science, IEEE Xplore, PubMed, and arXiv databases, covering publications from 2014 to November 2024. An initial pool of 356 records was screened, from which 43 studies met the inclusion criteria after a multi-stage selection process. The review addresses EEG databases, preprocessing techniques, feature extraction and selection strategies, and classification models. The studies are categorized into two main groups: (i) ML-based approaches, which rely on handcrafted features, and (ii) DL-based approaches, which automatically learn data representations. Reported performance outcomes, algorithms, and datasets are systematically compared. The findings indicate that while ML remains predominant, DL approaches are gaining prominence due to their capacity to model complex, large-scale EEG data. Nonetheless, challenges persist, including the scarcity of standardized datasets, limited cross-subject generalization, and the need for real-time, deployable systems. This review identifies these limitations, highlights emerging research trends, and proposes future directions, emphasizing the importance of benchmark datasets, subject-independent classification models, and interpretable AI for advancing EEG-based meditation recognition.

Keywords: electroencephalogram; meditation; machine learning; deep learning

Automotive Engineering

AI-based EFI System for Enhanced Fuel Efficiency in Single-piston Gasoline Engines

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Abstract

This study aims to design and develop a cost-effective AI-assisted Electronic Fuel Injection (EFI) system to enhance fuel efficiency and performance in single-piston gasoline engines. These types of engines are widely used in developing regions due to their simplicity and affordability. The system integrates an AI model with an ESP32-based electronic control unit to enable adaptive fuel delivery and custom designed throttle body with sensor mounts to make replaceable hardware kit. Importantly, the AI model operates independently from the ESP32 microcontroller. The ESP32 handles real-time data acquisition and communication and the AI model run externally by performing computational prediction tasks. Real-time sensor inputs such as engine RPM, throttle position, airflow rate, exhaust oxygen level, and engine temperature were processed to regulate injector pulse width. A dataset of over 4,000 engine samples was collected, processed, and used to train four regression algorithms such as linear regression, K-nearest neighbors, support vector machine, and gradient boosting regression. The models were evaluated using mean absolute error, mean squared error, and the coefficient of determination (R^2). Among these, the gradient boosting regression model achieved the highest prediction accuracy with an R^2 value of 0.9950, demonstrating superior performance in injector pulse-width prediction. A Python-based diagnostic interface, developed using the Tkinter library. It provided real-time monitoring of parameters, 3D fuel mapping, and data logging. The results confirm that integrating AI with EFI technology significantly improves efficiency and supports sustainable small-engine applications.

Keywords: intelligent fuel injection; machine learning; fuel optimization; emissions reduction; fuel injection

Biotechnology, Bioengineering, and Industrial Bioprocessing

pH-responsive *Chlorhexidine*-loaded MgO Nanoparticles Synthesized for Bimodal Oral Drug Release

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Abstract

The development of nanomaterial-based drug delivery systems has gained considerable attention. In this study, we synthesized magnesium oxide nanoparticles (MgONPs) from natural dolomite using a precipitation–calcination method and to evaluated their potential as nanocarriers for the controlled delivery of chlorhexidine (CHX). Specifically, the study compared two drug-loading techniques, incipient wetness impregnation (IWI) and absorption equilibrium (AE) in terms of their effects on drug entrapment efficiency, release behavior, and physicochemical characteristics of the CHX-loaded MgO nanoparticles. These synthesized materials were characterized using X-ray diffraction, scanning electron microscopy, Fourier-transform infrared spectroscopy, energy-dispersive X-ray fluorescence, and dynamic light scattering for particle size analysis. Based on the results, the X-ray diffraction analysis indicated an average crystallite size of MgO as 24.49 nm, while the scanning electron microscopy analysis, using ImageJ software, determined the particle size to be approximately 93.2 nm. Based on the drug loading methods, the AE method demonstrated significantly higher drug entrapment efficiency (68.30±0.82%) than the IWI method (51.97±0.47%) (t=29.93, $p< 0.001$). *In vitro* drug release studies were conducted by the dialysis method in both acidic (pH 5.5) and neutral (pH 7.4) phosphate-buffered saline during 31 hours. The results indicated that the AE method drug-loaded samples followed a Higuchi mathematical model, which indicated a diffusion-controlled mechanism. In contrast, the IWI method drug-loaded samples resulted in a bimodal release profile, with an initial burst release of up to 85% of the CHX drug within the first 5 hours at pH 5.5, described by the Korsmeyer-Peppas model, and a continued drug release with a second burst release, making it reliable for the rapid and localized antimicrobial action in oral cavity applications. This study highlights the potential of drug-loaded MgONPs as pH-sensitive drug carriers, with drug release ability controlled by the drug loading method.

Keywords: chlorhexidine; bimodal release; pH responsive; drug entrapment; dolomite; magnesium oxide nanoparticle

Green Synthesis, Characterization, and Dye Removal Applications of Cellulose-Zinc Oxide Nanocomposite using *Eichhornia crassipes* Extracts

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Abstract

Nanotechnology has been employed to develop new materials and devices with a diverse range of applications across various fields, including medicine, electronics, biomaterials, and energy production. Among many nanomaterials, the most studied material groups are metal oxide nanoparticles (MONPs). Zinc oxide nanoparticles (ZnONPs) are considered one of the most important MONPs due to their unique physical and chemical features and their broad applicability in many areas, including environmental remediation. The water pollution caused by industrial dye effluents, particularly from the textile and paper industries, is one of the major global issues. The removal of dye from water is difficult through traditional dye removal methods. Eichhornia crassipes (water hyacinth) has garnered considerable attention due to its rapid reproductive capacity, which has resulted in severe ecological damage in many eutrophic lakes worldwide. In the current work, the authors proposed the green synthesis of cellulose-ZnONPs nanocomposite (Cel-ZnONPs) derived from water hyacinth for dye removal applications. The nanocomposite (NC) was characterized using X-ray diffractometry, Fourier transform infrared spectroscopy and Scanning Electron Microscopy. The dye removal applications were tested using a model industrial dye, methylene blue (MB), using Ultraviolet-Visible spectroscopy. The size of the NC was between 100 and 320 nm. The equilibrium adsorption data fitted well to the Langmuir isotherm model, indicating the preferential monolayer adsorption. Our adsorption kinetics followed the pseudo-second-order kinetic model. The results demonstrated that the maximum dye removal efficiency of MB was 94.87% within 120 mins.

Keywords: green synthesis; nanocomposite; cellulose; zinc oxide nanoparticles; dye removal studies

In Silico Design of a CRISPR-Cas13 Synthetic Gene Circuit Biosensor for Early Detection of Breast Cancer Markers

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Abstract

Breast cancer continues to be a major contributor to cancer related mortality among women worldwide, emphasizing the urgent need for early and accurate diagnostic tools. The integration of molecular biomarkers and synthetic biology provides a promising avenue to enhance detection and intervention strategies. In this study, we report on the in-silico design and validation of a novel CRISPR Cas13 based biosensor integrated with synthetic gene logic circuits for the target detection of key breast cancer biomarkers. An interdisciplinary computational framework was employed, incorporating bioinformatics, genetic circuit engineering, and dynamic simulation. Using database mining from NCBI, three clinically relevant mRNA biomarkers HER2, MUC1, and EGFR were selected for target detection. Specific guide RNAs were designed to bind selectively to the transcripts of these markers through the CRISPR Cas13 enzyme system. logic gate based synthetic gene circuits (AND, OR, NOT) were developed using modular biological parts, including minimal promoters, transcription terminators, and fluorescent reporter genes such as GFP and RFP. The logical and dynamic behavior of the circuits was simulated using Ibiosim software, enabling analysis of system responsiveness, stability, and robustness. Simulation results confirmed the successful function of each logic gate: the AND gate exhibited high specificity by producing a signal only in the presence of both HER2 and MUC1, while the OR and NOT gates provided versatile detection configurations for broader diagnostic applicability. Signal outputs were consistent and robust across variable input conditions. The design was further conceptualized for integration into a microfluidic biosensor system with electrochemical or fluorescent readouts, supporting real time, point of care diagnostic applications. This study introduces a programmable, highly specific CRISPR Cas13 biosensing platform with potential for clinical deployment in breast cancer diagnostics, representing a foundational step toward smart, synthetic biology driven diagnostic devices for precision medicine.

Keywords: biosensor; breast cancer; CRISPR-Cas13; genetic logic gates; synthetic biology

Determination of Sun Protection Factor of Selected Herbal Materials and Development of an Organic Sunscreen

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Abstract

Ultraviolet (UV) radiation is a major environmental factor contributing to premature skin aging and carcinogenesis. Conventional sunscreens provide protection but often contain synthetic agents linked to allergies and environmental risks. This study evaluated the photoprotective potential of locally available herbal extracts and developed an organic sunscreen formulation. Ten ethanolic herbal extracts were analyzed *in vitro* using UV spectrophotometry (290–320 nm), and their Sun Protection Factor (SPF) values were calculated using the Mansur equation. Four extracts are *Mesua ferrea*, *Coscinium fenestratum*, *Santalum album*, and *Curcuma longa* showed SPF values above 35 at 8 mg/mL. These were incorporated into two emulsion-based lotions. Trial 1, formulated with stearic acid (10 g), cetyl alcohol (2 g), glycerin (5 g), sunflower oil (5 g), lanolin (2 g), and a 0.1 g blend of herbal extracts, produced a stable oil-in-water emulsion. Quality testing based on SLS 743:2014 confirmed superior thermal and oxidative stability and an *in vitro* SPF of 26.56±0.0006. Statistical analysis ($p < 0.05$) verified its significance compared with Trial 2. The results demonstrate that underutilized Sri Lankan botanicals can serve as effective, sustainable, and nature-friendly alternatives for developing high-performance organic sunscreens.

Keywords: sun protection factor; UV radiation; herbal sunscreen; spectrophotometry; organic formulation

Verification of ISO 19563:2017 High-Performance Liquid Chromatographic (HPLC) Method for the Detection and Quantification of Theanine Content in Sri Lankan Tea

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Abstract

Theanine (N-ethyl-γ-L-glutamine, also known as L-theanine) is a specific amino acid primarily found in tea (*Camellia sinensis*), which contributes to the unique umami flavor of tea and provides multiple health benefits, including promoting relaxation, improving focus, and enhancing sleep quality. Despite its significance, several analytical methods exist for quantifying theanine content in tea. This study presents a rapid and efficient ISO 19563:2017 HPLC standard method for verifying the acute detection and quantification of theanine content in Sri Lankan tea, eliminating the need for derivatization. Throughout this study, the verified method demonstrated excellent linearity (R^2=0.999) across the 5-100 µg/mL working range, with a limit of detection of 4.667 µg/mL and a limit of quantification of 14.143 µg/mL. Repeatability and reproducibility expressed as percentage relative standard deviation were 0.534% and 0.131-0.977% respectively, within the acceptable ranges. The method revealed high accuracy, with a mean recovery of 110.82% in spiked samples. Our results confirmed the applicability of this standard method for reliable quantification of theanine in Sri Lankan tea, supporting its broader use in quality control and research.

Keywords: theanine; amino acid; verification; HPLC; tea; umami

Comparative Study on the Influence of Titanium Dioxide and Calcium Carbonate Additives on the Physical Properties of Corn Starch-based Bioplastics

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Abstract

The growing environmental concerns associated with fossil fuel-based plastics have accelerated the development of sustainable alternatives such as bioplastics. This study investigates the effects of titanium dioxide (TiO_2) and calcium carbonate ($CaCO_3$) additives on the physical properties of corn starch–based bioplastics, focusing on varying concentrations ranging from 0% to 10%. Key parameters analyzed include moisture content, biodegradability, water absorption, and melting point, to identify application-specific performance enhancements. Results reveal that increasing TiO_2 concentration raise moisture content, while $CaCO_3$ addition results in a progressive decrease from 6% to 3.3%. A clear inverse relationship was observed between moisture content and biodegradability; $CaCO_3$-enhanced samples exhibited improved biodegradability, making them suitable for single-use and short-term packaging, while TiO_2 reduced biodegradation, suggesting applications in durable or long-term storage materials. Both additives contributed to a significant increase in melting point, broadening the functional range of these bioplastics to include high-temperature applications such as microwave-safe containers and automotive components. Water absorption declined with increasing concentrations of both TiO_2 and $CaCO_3$, indicating improved moisture resistance a desirable trait for food packaging and outdoor product applications. The contrasting moisture profiles offer tailored functionality: TiO_2-enhanced bioplastics may benefit horticultural or agricultural uses due to controlled moisture release, whereas $CaCO_3$-enhanced variants are better suited for electronics or dry goods packaging. This comparative analysis emphasizes the tunable nature of starch-based bioplastics through additive incorporation, laying a foundation for the targeted design of sustainable materials. The study highlights the potential for additive-modified bioplastics to replace conventional plastics across various industrial sectors, aligning with global sustainability objectives.

Keywords: bioplastics; titanium dioxide; calcium carbonate; physical properties

Salicylic Acid-induced Changes in Antioxidant and Antibacterial Activities of Medicinal Plants: *Bacopa monnieri* (Waterhyssop) and *Peperomia pellucida* (Pepper elder)

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Abstract

Salicylic acid is a phytohormone involved in plant metabolic pathways including immune responses, stress defense, respiration and bioactive compound production. Exogenous application of salicylic acid improves plant health and properties, including antioxidant, antimicrobial and photosynthetic properties. Foliar applications have been widely used for various applications, such as the delivery of nutrients and hormones, due to their effective and rapid plant response. In this study, effects caused by the foliar application of salicylic acid on two Ayurvedic medicinal plants used in Sri Lanka; *Peperomia pellucida* (Pepper elder) and *Bacopa monnieri* (Waterhyssop) were assessed. Three treatment groups; a control group treated with water, and two experimental groups treated with salicylic acid at 50 ppm and 100 ppm concentrations (n=16) were established. The treatments were carried out for eight weeks and the plant growth, chlorophyll content, antioxidant capacity, and antibacterial activity were assessed. Antioxidant potential was analyzed using the phosphomolybdenum and DPPH assays, while total phenolic and flavonoid contents were analyzed using Folin-Ciocalteu and aluminium chloride assays respectively. Well diffusion method was used against *Escherichia coli* and *Staphylococcus aureus* to analyze antibacterial activity. A dose-dependent increase in bioactivities was observed in Pepper elder, with 100 ppm salicylic acid resulting in the highest total chlorophyll (14.09±0.22 mg/g), phenolic (22.09±0.48 mg GAE/g), flavonoid (22.84±0.62 mg QE/g), antioxidant (12.65±0.65 mg AAE/g; DPPH IC_{50} 28.16±1.09 mg/mL) contents, and highest zone of inhibition against *S. aureus* (11.83±0.17mm). In Waterhyssop, the peak response was observed at 50 ppm, with corresponding values of 11.03±0.15 mg/g, 9.21±0.28 mg GAE/g, 11.83±1.50 mg QE/g, 7.18±0.35 mg AAE/g, DPPH IC_{50} 24.51±1.58 mg/mL, and 9.88±0.31 mm, respectively. Overall, these findings indicate a species-specific response to salicylic acid, with 50 ppm optimal for Waterhyssop and 100 ppm for Pepper elder. Therefore, salicylic acid treatment can be recommended to enhance the medicinal potential of these plants.

Keywords: antioxidant activity; antibacterial activity; salicylic acid; foliar application; *Peperomia pellucida*; *Bacopa monnieri*

Impact of Salinity Levels on the Growth Rate of Saline Tilapia in Cement Tanks

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Abstract

Saline tilapia is a hybrid fish species produced by crossing five different Oreochromis species, that provides an alternative solution for white spot disease management in shrimp farming systems. Culturing saline tilapia between two shrimp cycles can effectively overcome disease spread among the shrimp cycle, because saline tilapia not affected by white spot virus. Understanding the salinity tolerance of saline tilapia is essential because shrimps are cultured in saline water. This study investigated optimal salinity levels for saline tilapia growth performance to enhance aquaculture productivity and provide better solutions for white spot disease challenges in Sri Lankan shrimp farms. The research was conducted by observing the growth performance of saline tilapia under different salinity levels (0, 5, 10, 15, and 20 ppt) in controlled cement tank conditions. Weight gain and length increase were measured and statistically analyzed to determine significant differences between treatments. Results show that moderate salinity levels (10-15 ppt) optimize saline tilapia production by enhancing protein retention, digestive enzyme activity, and metabolic efficiency. Fish maintained at these salinity concentrations exhibited superior growth performance compared to freshwater and higher salinity treatments. The findings confirm that saline tilapia can effectively utilize brackish water environments for optimal growth and development. The results provide a valuable message for aquaculture management, particularly for integrating saline tilapia culture between shrimp farming cycles to reduce disease transmission while maximizing profit margins. This study contributes to sustainable aquaculture practices in Sri Lanka by identifying optimal environmental conditions for hybrid saline tilapia cultivation, supporting both disease control strategies and enhanced productivity in coastal aquaculture systems.

Keywords: saline tilapia; white spot disease; salt tolerance; stocking density; sustainable aquaculture

Development of a Compatible Packaging System for Solid Oral Tablets in Bulk Containers in the Pharmaceutical Industry

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Abstract

Pharmaceutical packing materials play an important role in ensuring product stability throughout shelf life in the pharmaceutical industry. This study aims to develop a compatible and already implemented material system, including primary, secondary and tertiary packing materials for a solid oral pharmaceutical drug formulation. The primary packing system, high-density polyethylene (HDPE) containers with plastic closures and wads, initially failed leak test at the standard sealing voltage of 160 V. This failure interrupted the commercialization process of the product. The container was made of pharmaceutical-grade HDPE, the closure from polypropylene-based material, and the wad includes an induction sealing foil with a pressure-sensitive sub-wad to ensure proper sealing performance. New closures produce with reduced total height and diameters, removing the tamper-evident band to improve seal ability. The pre-modification system shows only a 40-45% pass rate, while the modified closure achieves 100%, confirming the success of the redesign. Leach tests execute by UV absorbance measurement at 290-450 nm using ethanol and internal cleanliness tests with reverse osmosis water confirmed that the chemical safety and manufacturing hygiene of the revised system. Based on the finalized primary packing system, secondary (sticker labels) and tertiary (corrugated shippers) packing materials optimize to comply with physical specifications. This research study provided a systematic approach to resolving leak-test failures of primary packing materials, leading to the development of a compatible packaging system for solid drug formulations using locally sourced materials and enabling efficient drug packing processes.

Keywords: leak test; leach test; pharmaceutical industry; pharmaceutical packing materials

Investigation of the Oil Content in Desiccated Coconut (DC) using Fourier Transform Near-infrared (FT-NIR) Spectroscopy and the Effect of its Particle Size on Oil Content

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Abstract

The oil content of DC is a critical quality parameter influencing its stability, shelf-life, texture, and flavour. The oil content of DC is typically determined using the Soxhlet extraction technique, as outlined in the Association of Official Analytical Chemists Standard 948.22. This technique has several drawbacks, including high solvent usage, slow speed, and prolonged processing time. In the current study, FT-NIR was employed to determine the oil content of DC, utilizing a partial least squares (PLS) regression model. The model development was performed using a Thermo Scientific FT-NIR instrument. Calibration of the model was performed in the 7400 to 4200 cm^{-1} range, and upon calibration, the correlation coefficient (R^2) and root mean square error were 0.9803 and 1.70, respectively. The prediction of unknown oil concentrations was performed to determine the accuracy of the developed model. The mean oil content (%) of four unknown samples determined after the soxhlet extraction were 62.82, 59.70, 59.56, and 62.09%, respectively. The predicted values calculated from the developed PLS model were 63.82, 59.60, 57.98, and 57.18%, respectively. Therefore, the developed model performed well for unknown samples and can be used to predict the oil content in various DC samples. The effect of particle size of DC on oil content was also investigated using this technique, for different particle sizes, namely fine, medium, chiplet, and broken chips. The mean oil content of the DC samples is 59%, 61%, 63%, and 64% for fine, medium, chiplet, and broken chips, respectively, indicating that particle size has no significant effect on the oil content of DC during processing. The current study reveals that the FT-NIR technique and PLS model developed has the potential to be used as a simple and fast technique to determine the oil content of DC, replacing the conventional soxhlet extraction-based technique.

Keywords: Desiccated coconut; fourier transform near-infrared spectroscopy; particle size; oil content; partial least square regression

Glycation Reversing Potential of Crude Bark Extract and Fractions of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume) *In vitro*

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Abstract

Non-enzymatic reactions between reducing sugars and proteins lead to the formation of advanced glycation end products (AGEs), which contribute to the structural and functional alterations of macromolecules. These changes are strongly implicated in the pathogenesis of numerous non-communicable diseases and accelerate premature skin aging. Previous studies have already proven that crude bark extract (CBE) of Ceylon Cinnamon (CC) possesses glycation-reversing activity. However, to date, it has not yet been investigated for its fractions. Therefore, the present study investigates the glycation-reversing potential of CBE and fractions of (CC) *in vitro*. Alba-grade bark of CC was extracted with 95% ethanol, and the filtrate was concentrated and freeze-dried. The freeze-dried ethanol bark extract was subjected to the kupchan scheme of partitioning using hexane, ethyl acetate, and water. Glycation reversing activity of crude bark extract and its fractions was evaluated using Bovine Serum Albumin (BSA)-glucose and BSA-methylglyoxal (MGO) glycation reversing models (n=4 each). Rutin was used as a standard compound in both models. CBE and fractions (except hexane) exhibited significant ($p<0.05$) dose-dependent glycation-reversing activity in both models. However, the highest glycation reversing activity was shown in the (BSA)-glucose model for both CBE and its fractions. The IC_{50} values for BSA-glucose and BSA-MGO glycation reversing activities ranged from 30.21±1.19 to 68.80±3.42 µg/mL and 155.77±3.84 to 494.91±23.32 µg/mL. The ethyl acetate fraction demonstrated the most potent BSA-glucose glycation reversing activity (IC_{50}:30.21±1.19µg/mL), whereas the water fraction (IC_{50}:155.77±3.84 µg/mL) showed the highest BSA-MGO glycation reversing activity ($p<0.05$). Compared to rutin, both crude bark extract and fractions showed moderate glycation reversing activity in both BSA-glucose (18.11±0.32 µg/mL) and BSA-MGO (53.84±0.22 µg/mL) glycation reversing models. The order of potency for BSA-glucose and BSA-MGO glycation reversing activities was ethyl acetate> water> CBE and water> CBE> ethyl acetate, respectively. In conclusion, the results indicated that the CBE and fractions of CC possess moderate glycation-reversing activity, and further research is needed for the isolation and characterization of active compounds.

Keywords: glycation reversing activity; BSA-glucose glycation reversing activity; BSA-MGO glycation reversing activity; Ceylon cinnamon; fractions

Proteus mirabilis's Calcium-dominated Biofilm Encrustation on Urinary Catheters

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Abstract

Catheter-associated urinary tract infections (CAUTI) are among the most prevalent healthcare-associated infections, often exacerbated by urease-producing pathogens such as *Proteus mirabilis*. *P. mirabilis* raises urinary pH via ureolysis, driving Ca^{2+} and Mg^{2+} precipitation and crystalline biofilm formation. These crystalline biofilms are composed of calcium phosphate, calcium oxalate, and struvite. This process culminates in catheter encrustation, blockage, and premature failure. *P. mirabilis* typically coexists within polymicrobial communities, and its encrustation potential is influenced by interspecies interactions. This study aimed to investigate and compare Ca^{2+} and Mg^{2+} concentrations in crystalline biofilms on indwelling catheters from CAUTI patients colonized with *P. mirabilis* versus those without. This descriptive cross-sectional study was conducted at Colombo South Teaching Hospital, Kalubowila, Sri Lanka, enrolling 76 CAUTI patients following CDC 2024 criteria. Uropathogens were identified from catheterized urine and catheter tips using HiCrome™ UTI agar. Biofilm formation was quantitatively assessed using MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) and crystal violet assays. For elemental analysis, 30 catheter segments (1 cm each) were selected from the 76 samples, matched by catheterization duration and microbial profile (15 catheters with *P. mirabilis*, 15 without). Atomic absorption spectroscopy was conducted to quantify Ca^{2+} and Mg^{2+} concentrations in catheter-associated biofilms. Additionally, Energy Dispersive X-ray Spectroscopy, in conjunction with Scanning Electron Microscopy, was performed on a subset of catheter samples dominated by *P.mirabilis* to further analyze elemental composition and biofilm structure. *P. mirabilis* was detected in 47.37% of catheter samples, all within polymicrobial biofilms. In *P. mirabilis*-positive biofilms, moderate but non-significant correlations were found between catheter duration and Ca^{2+} and Mg^{2+} levels, with Ca^{2+} consistently exceeding Mg^{2+}. In *P.mirabilis*-negative biofilms, a moderate, non-significant correlation was also observed for Ca^{2+}, while Mg^{2+} showed a weak correlation. Mineral accumulation was lower and more variable in the absence of *P.mirabilis*. These findings suggest that *P.mirabilis* may enhance Ca^{2+}-dominated encrustation compared to biofilms lacking this organism.

Keywords: *Proteus mirabilis*; biofilms; calcium; magnesium; catheter encrustation; CAUTI

Scientific Validation of Traditional Use: Anti-inflammatory Activity of *Caryota urens* Aqueous Bark Extract via Protein Denaturation and HRBC Clot Lysis Assays

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Abstract

Caryota urens L., (*Arecaceae*), commonly known as Kithul, is native to South and Southeast Asia and has a long history of use in traditional Ayurvedic medicine. The bark is valued for its analgesic, antipyretic, wound-healing, and detoxifying effects, although scientific studies confirming these benefits are still scarce. On such a background, this study aims to evaluate the anti-inflammatory activity of *C. urens* aqueous bark extract using egg albumin denaturation and HRBC clot lysis assays. Plants were collected and authenticated, then using the maceration technique, the air-dried *C. urens* bark was powdered and extracted into distilled water 1:3 w/v ratio. A dilution series was created by diluting aqueous bark extract with distilled water in a range from 1.9-1000 $mgmL^{-1}$. Anti-inflammatory activity was evaluated via egg albumin denaturation and HRBC clot lysis assays, using diclofenac sodium and aspirin as positive controls in the egg albumin denaturation assay, and distilled water and saline as negatives in the HRBC clot lysis assay, wherein IC 50 values and the percentage of clot lysis were compared with the standard. Experiments were done in triplicate and were analyzed with GraphPad Prism 10. When considering the result of the egg albumin denaturation assay, the aqueous plant extract showed IC_{50}=30 $mgmL^{-1}$ with a strong correlation (R^2=0.95), while the standard (diclofenac sodium) IC_{50} was 180 $mgmL^{-1}$ and R^2 was 0.98. The aqueous plant extract showed significantly more potency than diclofenac sodium in this assay. In the HRBC clot lysis assay, the aqueous plant extract showed IC_{50}=30 $mgmL^{-1}$ and R^2=0.94, while the standard (aspirin) showed IC_{50}=570 $mgmL^{-1}$ and R^2=0.97. When the results of the HRBC assay are taken into consideration, at the highest concentration of plant extract tested (1000 $mgmL^{-1}$), the extract showed 59.6±13.8% clot lysis activity, more than double the standard's 26.7±9.86%, highlighting its promising therapeutic potential. This study validates the traditional use of *C. urens* bark for anti-inflammatory effects, demonstrating superior *in vitro* efficacy over standard drugs. Further work on isolating active compounds and assessing safety is recommended to develop its therapeutic potential.

Keywords: anti-inflammatory; *Caryota urens* L.; egg-albumin; HRBC clot lysis; herbal medicine; HRBC

Evaluation of the Effectiveness of Copper-based Fungicides on the Development of the Circular Leaf Spot Disease of Rubber

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Abstract

The circular leaf spot disease caused by the *Colletotrichum* spp. and *Pestalotiodes*, develops visible infections of brown or black color, pinpoint lesions that later expand to the whole leaf surfaces, resulting in leaf defoliation in rubber. Reports are available on the effect of the disease on the reduction of latex production. Chemical management is one of the tools in integrated disease management. Since circular leaf spot is a newly reported disease on rubber, limited research has been carried out to evaluate the fungicide effectiveness. Therefore, this study attempts to assess the effectiveness of copper-based fungicides: copper hydroxide and copper oxychloride on the management of the disease. The *in vitro* technique: detached leaf technique and the polybag nursery-level assessment were used in the study. The fungicide spraying, dipping applications were carried out on the leaves, and fungal plug, spore suspension inoculation methods were used. According to the results of the detached leaf technique, the most effective method was found as the fungicide spraying method for the fungal plug inoculation with wounded inoculation points. The avenue of copper-based fungicides with the lowest effective concentrations for managing disease pathogens is revealed as: 3 g/L for *Colletotrichum siamense* with fungicide combinations of copper hydroxide with COC (Sri Lankan) and copper hydroxide with COC (Indian), 0.1 g/L for *Colletotrichum fructicola* with fungicide combinations of copper hydroxide with COC (Sri Lankan) and COC (Sri Lankan) with COC (Indian). The polybag nursery-level assessment is not effective at higher concentrations of 50 g/L and 100 g/L due to a rise in disease. Also, no linear correlation between the concentrations observed in both tests. Therefore, this study highlights the requirement for further screening with other *in vitro* tests.

Keywords: circular leaf spot disease; fungicide screening; detached leaf technique; polybag nursery-level assessment; copper hydroxide; copper oxychloride

Awareness of the Impact of Microplastics on Marine Environment among University Students Aged 18-25 in Colombo District, Sri Lanka: a Cross-sectional Study

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Abstract

The United Nations Environment Programme (UNEP, 2023) projects that, if current trends persist, plastic inputs into aquatic ecosystems may triple by 2040, with significant and potentially irreversible impacts on marine biodiversity and human health. This study explored the awareness, perceptions, and behaviors of university students aged 18-25 in Colombo District, Sri Lanka, regarding microplastic contamination, emphasizing sustainable development and biotechnological monitoring. Using a mixed-methods approach guided by Saunders' Research Onion, the study combined survey data from 371 respondents with secondary literature on microplastic sources, environmental impacts and mitigation strategies. Findings revealed that 87.5% (n=325) had heard of microplastics, most commonly identified plastic packaging 32.4% (n=120) and synthetic clothing 7.2% (n=27) as sources of microplastics. However, chi-square analysis showed no significant link between general awareness and knowledge of specific sources (p=0.834), suggesting limited depth of understanding. Nearly all participants 99.7% (n=370) recognized their harmful effects on marine life and potential entry into the food chain. A strong correlation emerged between ecological awareness and their perceptions of associated human health risks (p<0.001), with 90% (n=334) expressing concern regarding potential health implications. Higher concern levels were significantly associated with eco-friendly behaviors like recycling and using reusable bags (p<0.01). Despite awareness of government plastic policies, these had minimal influence on actual practices, revealing a gap between knowledge and practice. The study underscores the need for targeted educational initiatives incorporating local case studies and biotechnology-based tools (e.g., spectroscopic detection, environmental DNA assays) to deepen scientific understanding and promote active engagement. Aligning efforts with sustainable development goal (SDG)14: life below water (reducing marine pollution and protecting eco systems) and SDG 12: responsible consumption and production (minimizing waste and promoting sustainable practices) can empower Sri Lankan youth as key agents in combating microplastic pollution and protecting marine biodiversity.

Keywords: microplastics; marine sustainability; environmental biotechnology; youth awareness; Sri Lanka

Formulation Development of Mosquito Repellent Gel Containing *Ocimum sanctum, Tagetes erecta* and *Mentha piperita* L.

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Abstract

In response to growing concerns over the health and environmental impacts of synthetic mosquito repellents, herbal formulations are gaining popularity as safer, eco-friendly alternatives. The present research is focused on formulating a DEET-free herbal mosquito repellent gel formulation using essential oils of *Ocimum sanctum* (Holy basil), *Tagetes erecta* (Marigold) and *Mentha piperita* L. (Peppermint). Three formulations (F1-3) were prepared and evaluated through a series of physicochemical assays such as pH, density, viscosity determinations and evaluation of the organoleptic characteristics (color, appearance, odor, phase separation and texture). Also, microbiological testing including total aerobic mesophilic microbial count, detection of *Candida albicans* and *Escherichia coli*. The organoleptic and physical stability of the formulations were observed over 14 weeks and the results demonstrated acceptable physicochemical and organoleptic stability throughout the tested period. Among the tested formulations F2, which contained 0.25% of active ingredients, was identified as the most stable and suitable candidate for conducting the mosquito repellency test, as it exhibited optimal physicochemical and microbiological properties essential for an effective and safe mosquito repellent gel. The F2 formulation demonstrated 100% repellency for 2 hours against mosquitoes indicating its suitability as a mosquito repellent.

Keywords: mosquito repellent; organoleptic properties; mosquito repellency test; deet-free

HPLC-based Stability Study of Reference Solutions Prepared using BP, USP, and EP Standards for Pharmaceutical Quality Control

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Abstract

Reference standards play a crucial role in pharmaceutical quality control analysis to ensure drugs' identity, potency, purity, quality, strength, and reliability of analytical results. The frequent preparation of reference solutions leads to high costs, extra time consumption and reduces the efficiency of the quality control process. Therefore, this study investigates the stability period of five reference solutions, Bisoprolol for Peak Identification European Pharmacopeia Chemical Reference Substances (EPCRS), Bisoprolol for System Suitability EPCRS, Bisoprolol for Impurity Standard British Pharmacopeia Chemical Reference Substances, Cetirizine Impurity A Chemical Reference Substance (CRS), and Chlorothiazide impurity A CRS to ensures the reliability and accuracy of analytical results while reducing the consumption of new reference standards. Five reference solutions were prepared and stored under controlled conditions (2-8 °C) for six months' time. High-Performance Liquid Chromatography is used to analyze their stability in each month, following the key parameters as per the relevant pharmacopeia. The results indicate that the selected reference solutions confirm their intended use over six months, complying with the accepted criteria with minor fluctuations of the relative retention time. This caused primarily due to the method validation process in the research and development phase, variations of mobile phase compositions, possible chemical interactions, and degradations of the components. This finding suggested that the pharmaceutical reference solutions can be stored under proper storage conditions for over six months beyond single-use preparations. This discovery may lead to enhancing the profit of the pharmaceutical company while reducing the cost associated with purchasing and importing new reference standards frequently.

Keywords: cost efficiency; chemical reference standards; drug quality control; high-performance liquid chromatography; pharmaceutical reference solutions; stability study

Building Construction and Infrastructure Technology

Evaluation of Durability Properties of Concrete Paving Blocks with Partial Replacement of Sand by Water Treatment Plant Sludge

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Abstract

This study investigates the potential of using Water Treatment Plant Sludge (WTPS) as a partial replacement for fine aggregate in the production of concrete paving blocks. The main objective was to evaluate the mechanical and durability performance of the paving blocks when sand is replaced with WTPS in varying proportions. The sludge used in this research was collected from the Wellimada water treatment plant, oven-dried, sieved, and utilized to replace natural sand by 5%, 10%, and 15% by weight. A mix ratio of 1:0.63:1.88:0.35 (cement: sand: coarse aggregate: water) was used for all the batches. Tests were conducted according to Sri Lankan Standard SLS 1425: 2011 specification for pedestrian grade paving blocks and included compressive strength, water absorption, and assessment of appearance. The test results showed that the addition of WTPS up to 10% enhanced both strength and durability properties. The 10% replacement mix recorded the highest compressive strength of 51.19 MPa and the lowest water absorption of 1.52%, which is about a 78% increase and a 57% reduction, respectively, compared to that of the control mix. This is due to the filler effect of fine sludge particles, which enhances particle packing and reduces porosity. However, a further increase to 15% WTPS showed a decline in performance due to increased internal voids and weaker interfacial bonding. All mixes satisfied the minimum strength and absorption requirements of SLS 1425:2011 for pedestrian applications. The results show that WTPS can serve effectively as a sustainable fine aggregate substitute for up to 10% paving blocks. The findings demonstrate that WTPS can serve effectively as a sustainable fine aggregate substitute up to 10% paving blocks. This approach encourages waste material reuse, minimizes environmental impact, and allows for circular economic practices within the construction industry.

Keywords: water treatment plant sludge; concrete paving blocks (CPB); durability properties; SLS 1144:2011 compliance; fine aggregate substitution

Shaping Tomorrow: Stakeholder Perspectives on 3D Printing for Custom Buildings in Sri Lanka

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Abstract

Sri Lanka's architectural practice is dominated by culturally driven, client-led personalized housing, with construction processes remaining largely manual. In contrast, global construction is rapidly adopting digital methods such as Construction 3D Printing (C3DP), offering faster delivery, reduced labor, lower material waste, and enhanced customization. This study investigates stakeholder perceptions on the feasibility of adopting C3DP within Sri Lanka's small-scale housing sector. A structured questionnaire was administered to 26 professionals including 14 architects, 10 engineers, and 2 contractors, assessing 60 factors considered vital for technology adoption. The results reveal both shared and divergent views: while C3DP is widely regarded as energy-efficient, labor-saving, and capable of faster project delivery, concerns remain about cost-effectiveness, material suitability for local housing culture, and rural acceptance. Contractors expressed the greatest skepticism, particularly regarding reliability and cost, whereas architects emphasized time efficiency and engineers highlighted workforce adaptability issues. Across professions, 15 adoption factors scored above 4.0 on a 5-point scale, including the need for policy support, observational confidence-building, and resolution of material and design limitations. The findings stress that successful adoption depends on addressing financial risks, training gaps, and cultural expectations, alongside technical readiness. This study provides an agenda for aligning emerging construction technologies with Sri Lanka's housing sector realities, bridging the gap between innovation and tradition.

Keywords: technology adoption; stakeholder perception; construction 3d printing

Graphene Oxide-enhanced Plastering Mortar with Improved Antifungal Performance

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Abstract

Plastering mortar is widely used for internal and external walls; however, conventional mortar is highly susceptible to fungal growth under damp conditions, leading to biodeterioration and reduced durability. This study investigates the incorporation of graphene oxide (GO) into plastering mortars to enhance its antimicrobial performance while maintaining workability and strength. Mortar specimens with 0.03, 0.06, 0.10, and 0.12% GO were prepared alongside control samples and those treated with a commercial antimicrobial agent. Antifungal resistance was assessed against *Aspergillus niger* using visual inspection, microscopic analysis, and spore count methods. Results confirmed a significant improvement in antimicrobial performance with GO addition. Microscopic analysis showed antibacterial activity increases of 21, 55, 77, and 69% for increasing GO levels, consistent with visual inspection findings. Spore count analysis revealed that the lowest fungal growth at 0.10% GO, while higher concentrations showed slight efficiency reduction due to agglomeration. The 0.10% GO-modified mortar surpassed the commercial antimicrobial agent, which was monitored for transient protection with subsequent fungal regrowth. Therefore, 0.10% GO is identified as the optimum dosage for maximizing antimicrobial efficiency, underscoring the potential of nanotechnology-enabled materials in developing durable, sustainable, and bio-resistant construction composites.

Keywords: graphene oxide; plastering mortar; antifungal performance; durability**;** *Aspergillus niger*; nanotechnology

Communication and Networking Technologies

Development of a Drone-based Navigation Analysis System for Aircraft Instrument Landing System (ILS) Inspection

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Abstract

Instrument Landing Systems (ILS) are essential for guiding aircraft during approach and landing, particularly under low-visibility conditions. This research proposes a cost-effective, drone-based solution for inspecting ILS signals using a compact system equipped with a Software Defined Radio, Raspberry Pi, GPS, and a LoRa communication module. The system captures and analyzes both localizer and glide slope signals in real time, extracting critical parameters such as difference in depth of modulation, sum of depth of modulation, and RF signal strength. These values are synchronized with GPS data and transmitted wirelessly to a ground station for visualization and analysis. In recent years, several aviation incidents have highlighted the risks of inaccurate or degraded navigational signals, particularly during final approach. Poorly calibrated ILS facilities can mislead aircraft and contribute to runway excursions or crash landings-scenarios that can be mitigated by regular inspection and validation. However, traditional ILS calibration methods involving manned flight inspections are expensive, time-consuming, and logistically limited. The proposed drone-based approach offers a safer, more accessible alternative, particularly beneficial for developing regions and secondary airports. Preliminary tests using simulated signals have validated the system's ability to capture and evaluate signal quality with location-based accuracy. Future work includes testing near operational ILS installations and refining the software algorithms for improved signal filtering. This system has the potential to significantly improve aviation safety by enabling more frequent and precise ILS inspections without the need for manned calibration flights.

Keywords: aircraft crash prevention; instrument landing system; RF signal strength; signal calibration; software defined radio

A VR-enhanced Car Modification Parts Finder with Intelligent Vehicle Recognition and Budget Optimization

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Abstract

The increasing demand for vehicle personalization in Sri Lanka has brought attention to the inefficiencies in identifying compatible car modification parts. This study introduces a Virtual Reality (VR) based car modification parts recommendation system that enhances the online customization experience through vehicle recognition, immersive 3D previews, and budget-aware filtering. By uploading a vehicle image, users can automatically detect their car model through intelligent image processing, after which the system suggests modification parts specific to that model. VR is used to simulate the installation of parts in a three-dimensional, immersive environment, allowing users to interact with their modified vehicle before purchasing. The platform also features a smart budget calculator that filters and ranks options within user-defined price ranges and integrates geolocation to highlight local part sellers. Evaluation of the system showed high accuracy in vehicle recognition, increased user satisfaction through realistic previews, and improved purchase confidence. Despite device-specific VR limitations, the system successfully addresses key pain points in the local car modification market and provides a foundation for scalable, intelligent, and user-friendly vehicle customization platforms.

Keywords: car customization; virtual reality; vehicle recognition; budget optimization; immersive e-commerce

Attachable UAV-based Signal Strength Enhancement Unit with Auto Positioning for Rescue Operations

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Abstract

Reliable wireless communication, especially 4G mobile signals in the 1800 MHz band, remains a challenge in rural, remote, and densely populated areas due to weak coverage and limited infrastructure. This issue becomes critical during rescue or emergency operations where stable connectivity is vital. Existing signal boosters are bulky, fixed, and lack adaptability, making them unsuitable for variable environments. To address these challenges, this study presents an attachable UAV-based signal enhancement unit with auto-positioning capability to improve communication reliability under low-signal conditions. The system is designed specifically for rescue operations and performs three key functions: transmitting victim's GPS coordinates using LoRa modules to rescue teams when the signal strength falls below -90 dB, boosting connectivity with a Lintratek GSM/4G amplifier when the signal is lower, and aligning the UAV toward the area of highest signal strength through an auto-positioning mechanism. A smart monitoring system allows users to monitor signal level, GPS location, and system status in real time. The design integrates an ESP32 microcontroller, directional and omnidirectional antennas, RF amplifiers, GPS, GSM, and accelerometer sensors for adaptive communication control. Field experiments confirmed that the amplifier increased signal strength from -115 dBm (25 ASU) to -95 dBm (25 ASU), while the LoRa-based link transmitted messages successfully over distances exceeding 10 km. The uniqueness of this project lies in combining signal boosting, low-signal LoRa communication, and auto-positioning UAV control into a single, compact, and portable system. These results validate the feasibility of the design for maintaining reliable communication in low-signal environments and demonstrate strong potential for rescue and disaster-response operations.

Keywords: UAV signal booster; LoRa communication; wireless signal enhancement; auto-positioning antenna; rescue operations

Robust and Secure Audio Data Hiding using Adaptive Temporal Masking and Multi-bit LSB Embedding

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Abstract

This paper presents a novel audio steganography technique that combines adaptive temporal masking with multi-bit least significant bit (LSB) substitution to achieve high-capacity, imperceptible, and secure data embedding in audio signals. The primary objective is to develop a high-capacity, imperceptible, and secure data embedding system resilient to common audio processing attacks and steganalysis. By leveraging psychoacoustic models of the human auditory system, the proposed method dynamically selects embedding locations within audio frames exhibiting temporal masking properties, allowing for the embedding of two bits per audio sample in a manner that preserves audio quality. The secret data is safeguarded through AES-128 encryption prior to embedding, enhancing security and robustness against unauthorized extraction. The model was evaluated using audio samples from the GTZAN dataset, preprocessed via peak normalization and resampling. Evaluation results demonstrate a substantial payload capacity of up to 25% relative to the audio file size, while maintaining excellent perceptual quality, evidenced by high PESQ scores (~4.6) and low spectrogram difference (2.4). The robustness of the method is reinforced by employing AES-128 encryption prior to embedding and is confirmed by high PSNR values exceeding 85 dB. Steganalysis tests further confirmed the system's undetectability through multiple steganalysis tools, including RS and Chi-Square attacks, which showed minimal statistical deviations, while power spectral density and hexadecimal fingerprint comparisons confirmed the absence of detectable embedding signatures, ensuring strong resistance to discovery. In conclusion, this approach effectively balances capacity, imperceptibility, security, and robustness, thereby providing a practical solution for secure audio communication. However, a key limitation is its vulnerability to lossy compression and intensive audio processing attacks, alongside its current restriction to WAV format and the use of AES in ECB mode. Future work will focus on improving robustness against such attacks, extending format compatibility (e.g., MP3), and adopting more secure encryption modes.

Keywords: audio steganography; audio data hiding; multi-bit LSB embedding

Energy, Environment, and Sustainability

Integrating Aspen Plus Simulation and Machine Learning for Predictive Optimization of Waste Heat Recovery

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Abstract

Waste heat recovery from boiler blowdown offers a significant opportunity to improve efficiency in thermal power plants. This study developed an integrated simulation-optimization framework combining Aspen Plus modelling with machine learning to optimize the performance of a lithium-bromide absorption chiller at the Lakvijaya power plant, Sri Lanka. By systematically simulating varying operational parameters, particularly generator temperatures ranging from 200 to 340 °C, the authors generated comprehensive performance data for machine learning model training. The results reveal that increasing the generator temperature enhances cooling capacity, with the evaporator duty rising from 638.18 to 1,739.89 kW, while the evaporator temperature peaks at 5.07 °C. The coefficient of performance (COP) exhibits a non-linear trend, reaching a maximum of 0.995 at 340 °C, indicating optimal efficiency at higher temperatures. However, the generator duty peaks at 320 °C before declining, suggesting potential thermal limitations. A Random Forest algorithm achieved a high predictive performance ($R^2 \approx 0.95$) for the COP, enabling real-time optimization without repeated simulations. The developed web-based monitoring system provides plant operators with dynamic performance predictions, offering a practical pathway for industrial implementation. This integrated approach demonstrates the potential for data-driven optimization in waste heat recovery systems and broader applications in sustainable industrial energy management.

Keywords: waste heat recovery; machine learning; Aspen Plus simulation; boiler blowdown; absorption chiller plant

Development and Characterization of Sustainable Bricks using Fly Ash, Clay, and Water Hyacinth-derived Biochar

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Abstract

This study investigates the development and comprehensive characterization of sustainable bricks incorporating water hyacinth-derived biochar (WH-BC) into a matrix of fly ash (FA) and clay. The rapidly growing construction sector requires durable, efficient, and environmentally sound alternatives to conventional materials. Although FA utilization is a common waste management practice, concerns persist regarding the potential leaching of heavy metals from the brick matrix. In this work, WH-BC, a carbon-rich product of pyrolysis (yield: 34.64%), was employed as an immobilizing agent for metallic contaminants while enhancing structural properties. Six distinct brick mixtures were prepared, featuring a fixed 40% FA content combined with varying amounts of WH-BC (5, 10, and 15% by weight), alongside a clay-only control and a raw dried water hyacinth comparison. The bricks were evaluated through tests for compressive strength, water absorption, bulk density, and heavy metal leachate concentration using the toxicity characteristic leaching procedure. Results confirmed that the integration of WH-BC effectively addressed both environmental and structural challenges. The optimal composition, 50% clay, 40% FA, and 10% WH-BC, achieved the best balance of properties, with a compressive strength of 1.456 MPa, bulk density of 1.4871 g/cm^3, and water absorption rate of 19.3%. This performance makes the material suitable for non-load-bearing applications such as interior partition walls and decorative masonry. Moreover, the 10% biochar inclusion substantially reduced heavy metal release, with all leachate concentrations falling below WHO limits. This study demonstrates the potential of converting invasive water hyacinth and FA into sustainable construction materials, promoting circular economy principles within the building industry.

Keywords: biochar bricks; fly ash utilization; water hyacinth waste; heavy metal immobilization; non-load-bearing applications

Evaluating the Effectiveness of Selected Local Plant-based Coagulants in Treating Turbid Water in Sri Lanka

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Abstract

Turbidity remains a persistent obstacle to water usability in many Sri Lankan rivers, especially during the monsoon season when sediment loads surge. This study explores the untapped potential of locally available plant-based coagulants to reduce turbidity in river water for domestic purposes. Building on traditional knowledge and recent botanical insights, the research evaluates six natural materials: previously studied *Moringa oleifera* seeds, *Azadirachta indica* (neem) leaves, and *Citrullus lanatus* (watermelon) rinds, along with three newly investigated barks from *Terminalia arjuna, Madhuca longifolia*, and *Hibiscus tiliaceus*. Their performance was benchmarked against aluminium sulfate (alum) using standard jar test procedures. Water samples from the Nilwala River in southern Sri Lanka were treated under controlled lab conditions, testing coagulant dosages of 10-50 mg/L and settling times of 2, 4, and 24 hours. Alum showed the highest turbidity removal (up to 96%) with consistent performance. Among plant-based coagulants, *M. oleifera* seeds showed the highest turbidity removal (90%) at 10 mg/L after 24 hours. *H. tiliaceus* bark followed (80%), along with *M. longifolia* (78%) and *T. arjuna* (74%) under similar conditions. In contrast, *A. indica* and *C. lanatus* were less effective, each achieving up to 60% turbidity removal under optimal conditions. While Alum remains the most efficient, certain natural coagulants, particularly Hibiscus and Moringa, demonstrated strong potential as sustainable alternatives for decentralized water treatment in rural or underserved areas. These findings highlight that even small-scale, low-tech interventions using locally sourced plant materials can lead to meaningful improvements in water quality while promoting affordable and eco-friendly water management in Sri Lanka.

Keywords: eco-friendly water treatment; natural coagulants; turbidity removal; sustainable purification; plant-based solutions; affordable water treatment

Factors Influencing the Willingness to Buy Electric Vehicles among Non-EV Users in Sri Lanka

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Abstract

The growing global focus on renewable energy and sustainability has increased interest in electric vehicles (EVs) in the transportation sector. Recently, in Sri Lanka, EVs have become a prominent topic, and importers have shifted to importing EVs under well-known brands. This study aims to identify the factors influencing the willingness to buy EVs among non-EV users in Sri Lanka. A structured survey was administered via Google Forms, yielding 142 valid responses. Of these responses, 106 were selected for analysis based on the inclusion criterion of being non-EV users. Due to screening criteria and low response rates sample size was low (n=106). A convenience sampling strategy was employed for data collection. For data analysis, Minitab statistical software was employed. To identify the association between the willingness to buy an EV (response variable) and various independent variables, a chi-square test was performed. The chi-square test indicated a significant association between willingness (significance level=0.1) to buy an EV and the factors of environmental protection (p=0.007), ease of handling (p=0.018), and expected popularity of EVs (p-value=0.000). To examine the strength and direction of the associations, a binary logistic regression model was used. The regression analysis revealed that environmental protection (p=0.068) and expected popularity (p=0.003) were significant predictors of willingness to buy an EV under a 0.1 level of significance. Ease of handling didn't show a relationship in the regression model (p=0.305). The results showed that individuals who believe EVs support environmental protection are 2.5 times more likely to be willing to buy an EV, and popularity is almost four times more likely to show willingness. These findings provide valuable insights for stakeholders and policymakers to promote EVs in Sri Lanka, highlighting public awareness, environmental benefits, and concerns related to handling and usability.

Keywords: electric vehicles; consumer behavior; non-EV users; sustainable transportation

Investigating Photocatalytic Dye Degradation and Antibacterial Activity of Fe_2O_3 Nanoparticles

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Abstract

Iron oxide nanoparticles are studied in various fields of chemistry due to their versatile properties. This study focuses on synthesizing α-Fe_2O_3 nanoparticles through a co-precipitation method and studying their potential in photocatalytic degradation of methylene blue dye as well as antibacterial activities. These nanoparticles were synthesized by utilizing ferric chloride and sodium dodecyl sulfate in a basic medium, followed by calcination. FTIR analysis revealed characteristic Fe-O stretching at around 601 cm^{-1}, suggesting the formation of Fe_2O_3 nanoparticles. XRD analysis showed sharp diffraction peaks at 2θ values of 30.22°, 31.77°, 35.71°, 45.49°, and 62.97°, which are attributed to (220), (104), (311), (400), and (214) planes of α-Fe_2O_3 nanoparticles, respectively, and they are in the cubic phase. The average crystallite size of these nanoparticles was calculated using the Debye-Scherrer equation and found to be 41.41 nm. These chemically synthesized nanoparticles were then assessed for their antibacterial activity against Gram-negative *Escherichia coli* and Gram-positive *Staphylococcus aureus* through the disc diffusion method using nutrient agar as the medium. Inhibition zones were observed at minimum inhibition concentrations of 6000 ppm for *E. coli* and 4000 ppm for *S. aureus*, indicating their effective antibacterial activity against both strains. These Fe_2O_3 nanoparticles were also evaluated for their effectiveness in photocatalytic degradation of methylene blue dye under optimum conditions of pH 10 with a catalyst load of 9 mg and a dye concentration of 5 ppm, over a period of 3 hours under solar irradiation. During this study, these nanoparticles showed an effective dye degradation of 66.6%, which is 61.5% higher than that of the control. Different studies have been carried out to assess the photo degradation ability of Fe_2O_3 nanoparticles on textile dyes. However, this study signifies the feasible optimized conditions and enhanced dye degradation potential of these nanoparticles under direct solar light. Overall, these findings demonstrated that the synthesized Fe_2O_3 nanoparticles have the potential to act as promising environmental remediation tools by acting as antibacterial agents against certain bacterial strains, as well as potential dye degradation agents to remove common textile dyes through photocatalysis.

Keywords: nanoparticles; iron oxide; antibacterial activity; photocatalysis; dye degradation

Developing and Optimizing Sequencing Batch Reactor Systems for Sustainable Wastewater Management

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Abstract

Sequencing batch reactor is a fill-and-draw type modified activated sludge system for wastewater treatment. This research highlights the effectiveness of Sequencing Batch Reactor (SBR) technology in industrial wastewater treatment, focusing on nutrient (Nitrogen and Phosphorus) removal, which is crucial for preventing eutrophication due to algal blooms. SBR systems offer a cost-effective, flexible, and environmentally friendly solution by integrating multiple treatment stages (anaerobic, aerobic, and anoxic) within a single reactor to achieve high biological treatment efficiency. This study was conducted with two operations. Operation 1 was conducted at a cycle time of 5 hours, consisting of 5 distinct phases: a filling phase, a 1-hour anaerobic phase, an aerobic phase of 3 hours, a settling phase of 1 hour and a decanting phase. Operation 2 was conducted at a cycle time of 7 hours, consisting of total 6 distinct phases; a filling phase, a 1.5-hour anaerobic phase, a 3-hour aerobic phase, a 1.5 hour anoxic/mixing phase, a 1 hour settling phase and a decanting phase. Key water quality parameters were analyzed for both raw and SBR treated water batchwise, including pH, chemical oxygen demand (COD), total dissolved solids (TDS), total suspended solids (TSS), ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), and total phosphate (TP). The results indicate significant reductions in pollutant levels in both operational phases. However, Operation 2 showed improved treatment efficiencies along with average COD, ammonium, total inorganic nitrogen (TIN), TP, TSS, and TDS removal efficiencies of 82, 61, 35, 37, 81, and 20%, respectively. The enhanced performance in Operation 2 stems from the anoxic phase, which improved denitrification, reducing TIN by facilitating nitrate conversion to nitrogen gas, and enhanced phosphorus uptake by phosphorus-accumulating organisms under alternating anaerobic-aerobic-anoxic conditions. These findings highlight the effectiveness of SBR technology for removing organic matter and nutrients, offering a sustainable approach on wastewater treatment sector.

Keywords: sequencing batch reactor; wastewater treatment; nitrification; denitrification; phosphorus removal

Heat Stress in Cattle of Northern Sri Lanka: Physiological, Productive, and Reproductive Impacts, Adaptation Strategies, and Research Gaps in a Warming Dry Zone

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Abstract

Heat stress is an increasingly critical concern in cattle production systems, particularly in tropical and subtropical regions like Sri Lanka, where high ambient temperatures and humidity prevail. Rising global temperatures due to climate change have intensified the frequency and severity of heatwaves, negatively impacting animal welfare, health, productivity, and reproductive performance. This review aims to comprehensively analyze the causes, risk factors, physiological effects, and mitigation strategies associated with heat stress in cattle, with an emphasis on its relevance to Sri Lanka's dairy and beef industries. Core heat stress drivers include elevated temperature-humidity index (THI), prolonged solar radiation, inadequate shade, poor ventilation, and limited water availability. Physiological responses such as increased respiration rate, reduced feed intake, hyperthermia, and hormonal imbalances lead to decreased milk yield, growth retardation, compromised immunity, and infertility. Studies indicate that milk production can drop by up to 35% under severe heat stress conditions. Reproductive parameters such as conception rate and estrus expression are also significantly impaired. A statistically significant ($p<0.05$) correlation exists between THI and reduction in feed intake, milk yield, and fertility metrics. Mitigation strategies reviewed include shade structures, misting and fan systems, nutritional supplementation (electrolytes, antioxidants), selective breeding for heat tolerance, and real-time monitoring tools such as wearable sensors and remote THI alerts. Adoption of these strategies has shown measurable improvement in performance indicators under heat stress conditions. This review is based on a comprehensive literature survey of peer-reviewed articles retrieved from Scopus, PubMed, ScienceDirect, and Google Scholar databases, with an emphasis on tropical cattle systems. In conclusion, addressing heat stress is crucial for sustaining livestock productivity under changing climatic conditions. Future perspectives include integrating climate-smart livestock systems, enhancing genetic resilience, and improving farmer awareness through technology and policy support to build adaptive capacity in heat-prone regions.

Keywords: heat stress; physiological; production; reproduction; temperature-humidity index

Comparative Analysis of Green Synthesized MgO and CaO Nanoparticles on Antibacterial Activity and Transesterification of Sunflower Oil

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Abstract

Alkaline earth metal oxide nanoparticles (NPs) have gained significant attention due to their enhanced properties in various applications. This study focuses on synthesizing MgO and CaO NPs using peel extracts of *Citrus sinensis* (orange) and *Musa acuminata* (*ambul kesel*), respectively. The FTIR analysis showed a peak around 554 cm^{-1} for MgO NPs and a peak around 600 cm^{-1} for CaO NPs, which indicate metal-oxygen stretching vibrations. XRD analysis suggested that both NPs are crystalline and in the cubic phase. Based on the Debye-Scherrer calculations, the average crystallite sizes of MgO NPs and CaO NPs were found to be 10.29 and 37.62 nm, respectively. The surface morphology of both NPs was examined using SEM analysis, revealing an irregular shape, likely due to agglomeration. The antibacterial activities of both NPs were evaluated against gram-positive *Staphylococcus aureus* and gram-negative *Escherichia coli* strains using the disk diffusion method with nutrient agar as the medium. The results indicated that MgO NPs showed antibacterial activity against both strains, with a Minimum Inhibition Zone of 5000 ppm (8±0.5 mm) for *E. coli* and 900 ppm (9±0.5 mm) for *S. aureus*. In contrast, CaO NPs showed antibacterial activity only against *S. aureus* with a MIC of 15000 ppm (7±0.5 mm). These NPs were also evaluated for their potential in catalyzing the transesterification of sunflower oil under optimum conditions of oil-to-methanol ratio of 1:3 and catalytic load of 15 mg. The percentage yield of biodiesel using MgO NPs was found to be 87.75 % (w/w), while that of CaO NPs is 93.87% (w/w). These findings show that common household waste materials can effectively be utilized to synthesize MgO and CaO NPs with dual functionality as potent antibacterial agents and as green catalysts in the transesterification of sunflower oil. Moreover, this approach offers a sustainable and eco-friendly pathway to add value to common household waste, transforming it into useful nanomaterials that contribute to green chemistry and environmental sustainability.

Keywords: antibacterial activity; green synthesis; nanoparticles; transesterification; waste management

Analyzing the Potential of Water-hyacinth and Habarala for Paper Production

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Abstract

The increasing demand for paper products has led to significant environmental challenges, including deforestation, high energy consumption, and pollution. This study explores the feasibility of using invasive aquatic weeds such as Water-hyacinth (*Eichhornia crassipes*) and Habarala (*Alocasia mycorrhizas*) as sustainable raw materials for paper production. Using chemical processing and natural binding ingredients like okra glue, these plants which are frequently seen as environmental annoyances were turned into pulp. Five paper samples were created and evaluated for density, tensile strength, and moisture content, and biodegradability using different proportions of Water-hyacinth and Habarala pulp. Density measurements revealed that the papers produced with only water hyacinth paper (50 g), achieved the highest density of 1.23 g/cm³, while the paper, produced with 25 g Water-hyacinth and 25 g Habarala, showed the lowest value of 0.57 g/cm³, indicating differences in fiber compactness. Tensile strength tests showed that the papers produced with only water hyacinth had the highest mechanical strength of 47 MPa, making it suitable for durable applications. The blended samples also showed intermediate properties. Samples with high moisture content showed 8.5-10% lower moisture levels and comparable biodegradability of 82-85%. All samples approached industry standards, confirming their viability as environmentally friendly alternatives to traditional wood-based papers. This study emphasises how using invasive species to produce paper has two advantages, it lessens the ecological impact of the species while lowering the need for deforestation. Further optimization of fiber blends and methods for industrial applications is suggested by the findings, which also support the possibility of scalable, sustainable paper manufacture.

Keywords: Water-hyacinth; Habarala; sustainable paper production; invasive species; biodegradability; eco-friendly; deforestation reduction; alternative pulp sources

Investigating Efficiency of γ-Aluminum Oxide Nanoparticles on Antibacterial Activity and Transesterification of Sunflower Oil

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Abstract

Aluminum oxide nanoparticles (Al_2O_3 NPs) have gained considerable interest as main group metal oxides in various fields of study, due to their unique combination of properties such as thermal stability, biocompatibility, and electronic properties. In this study, γ-Al_2O_3 NPs were synthesized via a facile sol-gel method, and their efficiency in antibacterial activity and transesterification of sunflower oil was assessed. These NPs were synthesized by using anhydrous aluminum chloride and citric acid as precursors, followed by calcination. FTIR analysis of NPs showed a peak at around 571 cm^{-1} which implicates the presence of Al-O stretching vibrations, suggesting successful formation of Al_2O_3 NPs under applied conditions. XRD study exhibited distinct peaks at 2θ values of 19.34°, 32.30°, 37.56°, 45.81°, 60.88°, and 66.92° that are in accordance with (1 1 1), (2 2 0), (3 1 1), (4 0 0), (5 1 1), and (4 4 0) Miller indices of γ-Al_2O_3 NPs in cubic phase. Based on the Debye-Scherrer equation, the average crystallite size of NPs is calculated to be 4.57 nm. SEM imaging showed irregular flake- or sheet-like morphology of Al_2O_3 NPs, possibly due to an aggregated structure. These chemically synthesized γ-Al_2O_3 NPs were assessed for their antibacterial activity against gram-positive *Staphylococcus aureus* and gram-negative *Escherichia coli* bacteria by disk diffusion method using nutrient agar as the medium. This study showed clear zones of inhibition with minimum inhibitory concentrations of 10000 ppm for both *E. coli* and *S. aureus,* demonstrating their moderate antibacterial efficacy. The catalytic activity of these γ-Al_2O_3 NPs in the transesterification of sunflower oil was also evaluated. Results showed effective conversion of triglycerides to biodiesel with 83.76% (w/w) conversion efficiency. These findings primarily indicated the potential of γ-Al_2O_3 NPs to act as an antibacterial agent against certain bacterial strains and their ability to catalyze transesterification reactions. Overall, this study highlights the importance of synthesizing nanomaterials that have the potential to be utilized as tools to reverse bacterial environmental pollution and in renewable energy applications.

Keywords: antibacterial activity; γ-Al_2O_3 nanoparticles; sol-gel method; transesterification

Regulatory and Economic Instruments for Circular Waste Governance: A Case Study in Sri Lanka

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Abstract

Sri Lanka's shift towards a circular economy presents both unique challenges and opportunities for implementing effective circular waste governance frameworks. This study examines the regulatory and economic instruments in Sri Lanka's waste management sector and assesses their effectiveness in supporting circular waste practices. Data were collected through a combination of desk research, key informant interviews, and document analysis. The desk review covered national policy documents, legal frameworks, strategy papers, and program reports related to solid waste management and circular economy initiatives, including the national waste management policy (2019), national post-consumer plastic waste management program, Pilisaru project, and the Extended Producer Responsibility (EPR) roadmap. According to the data obtained, the key regulatory instruments analyzed demonstrated significant efforts to institutionalize circular waste principles. Economic instruments reviewed include the EPR roadmap with mandatory reporting and collect-back mechanisms, subsidies for eco-friendly products, import restrictions on used electronics, and PET/HIPS recovery partnerships. Further, the study recognizes success factors for circular waste governance in developing economies, comprising stakeholder commitment across proper and casual sectors, adaptive regulatory frameworks that accommodate local conditions, and economic incentives aligned with national development priorities. However, persistent barriers include insufficient implementation mechanisms, limited financial resources, and institutional capacity constraints that deter real implementation of circular instruments.

Keywords: circular economy; regulatory instruments; economic instruments

Innovative Utilization of Dairy Waste in Biodegradable Packaging Material Production

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Abstract

As an alternative to plastic waste, this study aimed to develop biodegradable packaging materials using market-rejected dairy waste (curd and yoghurt) with glycerin, corn starch, vinegar, and Napier grass (*Penicetum purpureum*). The effects of these components on the mechanical, physical, chemical, morphological, and biodegradable properties for packaging applications were evaluated. The process involved mixing dairy waste, dried Napier grass, glycerin, vinegar, and corn starch, heating the mixture to a boiling point with continuous stirring, pouring it onto the surface, and sun-drying the biodegradable packaging material. Nine treatments (T1-T9) were tested, varying the curd-to-yoghurt ratios (C: YR) (1:2, 1:1, and 1:4), glycerin content (GC) (5, 7.5, and 10 g), and drying time (DT) (6, 7, and 8 hours). Treatment 9 (C: YR 1:4, GC 10 g, and DT 8 hours) had the highest thickness (1.2±0.1 mm) due to the higher glycerin and yoghurt contents, while Treatment 1 (C: YR 1:2, GC 5 g, and DT 6 hours) had the highest moisture content (22.2±0.3%). Also, Treatment 9 showed the highest water absorption capacity (36.5±3.0%), which may have reduced mechanical strength. Degradation was examined by 28 days of soil burial, where Treatment 3 (C: YR 1:2, GC 10 g, and DT 8 hours) degraded the fastest, while Treatment 8 (C: YR 1:4, GC 7.5 g, and DT 7 hours) degraded the slowest. Overall, Treatment 5 (C: YR 1:1, GC 7.5 g, and DT 7 hours) showed the best performance by effective biodegradation and superior tensile strength and Young's modulus (0.09±0.04 and 0.36±0.04 MPa). Fourier transform infrared spectroscopy confirmed key functional groups, indicating the presence of proteins, starches, plasticizers, and their interactions. For the selected treatment, scanning electron microscopy images showed an irregular surface with non-uniform fiber distribution, a rough texture, and noticeable cracks. Together, these tests provided critical insights into the chemical composition and microstructure, which are essential for understanding the strength, performance, and biodegradability of the selected paper material.

Keywords: dairy waste; biodegradable packaging material; sustainability; innovation

Performance Evaluation of Cement-and Gypsum-based Composites Incorporating Coconut Fiber and Rice Husk Ash for Sustainable Building Applications

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Abstract

The aim of the study to develop a sustainable construction sheet incorporating agricultural waste in cement and gypsum, and to evaluate its mechanical properties, and overall durability for acceptability in construction applications. There are three different binder mixtures prepared by combining gypsum and ordinary Portland cement in a 7:3 ratio and partially replacing that mixture with rice husk ash at 10, 20, and 30% by weight. Each binder type was further modified by adding coconut coir fiber at 0, 5, 10, and 15% by weight.

The samples were tested for water absorption, bulk density, flammability, and flexural strength after 28 days of hydration. The water absorption test showed that water absorption increased with higher fiber content, with values ranging from 49.41 to 91.57%, due to the increased porosity caused by insufficient fiber and gypsum matrix bonding. Bulk density decreased as the amounts of fiber and ash increased, with the highest recorded at 0.9363 g/cm³ and the lowest at 0.6209 g/cm³, indicating the production of lighter materials. The mechanical performance, evaluated through flexural strength testing, showed that the addition of coconut fiber helped improve crack resistance and flexibility of the composites, with the highest recorded value at 3.457 MPa and the lowest value at 1.031 MPa. However, excessive fiber content slightly reduced overall strength due to poor dispersion and increased void formation. Flammability tests confirmed that all sheets exhibited self-extinguishing behaviors without continuous burning. The findings show that both coconut coir fiber and rice husk ash can be used with gypsum cement-based composites, supporting waste management in the building sector and the agricultural sector, while providing sustainable alternatives for non-structural construction applications.

Keywords: gypsum cement composites; coconut coir fiber; fiber reinforced composites; rice husk ash; green construction materials

Linking Incentives to Smart Environmental Practices: Pathways to Sustainability in Agri-food SMEs

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Abstract

Environmental Management Practices (EMPs) are becoming increasingly essential for enhancing sustainability, energy efficiency, and environmental resilience within small and medium-sized enterprises (SMEs), particularly in resource-intensive agri-food sectors. This study examines the level of smart EMP adoption, classified as strategic, tactical, and operational, and investigates how market, regulatory, and judicial incentives influence sustainability-oriented actions among agri-food SMEs in Sri Lanka's North-Western Province. Data were gathered from 50 SMEs through a structured questionnaire comprising 21 EMP indicators and five incentive dimensions: cost implications, sales and revenue benefits, liability laws, existing government regulations, and anticipated regulations. An incentive index (ranging from -1 to +1) was developed to measure adoption intensity, and multiple linear regression analysis was conducted after testing data normality. Findings reveal that only market-based incentives, specifically sales and revenue gains (β=0.594, p<0.001), significantly influence EMP adoption, whereas regulatory and judicial pressures remain largely ineffective. The study thus empirically confirms that market-based incentives play a decisive role in promoting smart environmental practices, emphasizing that sustainability transitions in agri-food SMEs depend on policies that align environmental sustainability with business value creation. Mechanisms such as green financing schemes, eco-label certification, and sustainability-linked procurement can incentivize wider adoption of smart EMPs. These practices not only reduce environmental impact but also improve competitiveness and long-term resilience.

Keywords: smart environmental practices; small and medium enterprises; sustainability adoption; incentive-driven behavior; environmental policy

Development of an Energy-efficient Wastewater Treatment Process with Downflow Hanging Sponge Reactor

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Abstract

Discharging large volumes of domestic and industrial wastewater causes severe nutrient enrichment, oxygen depletion, and ecosystem degradation. Developing suitable wastewater treatment technology is challenging due to the high cost and technical constraints. This study aimed to establish a low-cost, mechanical aeration-free wastewater treatment process using the Downflow Hanging Sponge (DHS) reactor concept. The experimental system consisted of two cylindrical DHS reactors in series: firstly, the open DHS reactor, which had aeration holes in the reactor wall and enabled passive aeration of the treated wastewater; and then the closed DHS reactor, without aeration holes, maintained anaerobic conditions. Initially, the sponge media was inoculated with sludge-inhabiting bacteria, and the experiment was conducted with raw municipal wastewater for 120 days at 4 hours hydraulic retention time and organic loading rate of 4 kg COD $m^{-3}day^{-1}$. At the end of the experimental period, the Mixed Liquor Suspended Solid (MLSS) analysis was carried out for both reactors separately to identify the colonization level of microorganisms. The developed system achieved 53% total inorganic nitrogen (TIN) removal efficiency, along with 88% COD, 77% ammoniacal nitrogen, 88% total suspended solids, and 55% of total phosphate removal efficiencies. Moreover, the average pH level was maintained at 7.5 in the effluent, and the average dissolved oxygen (DO) level in open and closed DHS reactors was 3 and 1.5 mg/L, respectively. The open DHS carried out organic removal and nitrification with a high DO level and established ammonia-oxidizing bacteria and heterotrophic bacteria. The closed DHS prevented external aeration, which created anaerobic conditions and facilitated the denitrification, and finally achieved high TIN removal efficiency (53%). The MLSS level showed >2000 mg/L, which indicates the reactor media has high microbial abundance. All treated effluent parameters met Sri Lanka's national discharge standards, demonstrating the system's potential as a cost-effective, sustainable wastewater treatment alternative.

Keywords: DHS; nitrogen removal; organic removal; wastewater treatment

Ambient Air Pollution Levels and Trends in Selected Urban Areas in Sri Lanka, from 2020 January to 2023 June

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Abstract

Increasing urbanization and traffic growth have escalated air pollution, emerging as a major environmental and health concern in Sri Lanka's urban areas. Mainly transportation sector is responsible for majority share of the gaseous emissions to the environment. Therefore, this attempt has been made to discuss the air pollution due transportation sector at in Colombo (Battaramulla) and Kandy, Sri Lanka, from January 2020 to June 2023. This study provides an integrated assessment of air quality, focusing on pollution levels and trends in Colombo (Battaramulla) and Kandy from January 2020 to June 2023. The research analyzes the temporal dynamics of key pollutants; particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), and ozone (O_3) and quantifies a localized vehicular emission inventory for critical road corridors in both cities. For this, secondary, hourly concentration data over 30 months from air quality monitoring stations were analyzed using statistical software. A bottom-up, time-based emission factor approach utilized manual traffic surveys and country-specific emission standards collected from the Central Environmental Authority of Sri Lanka. Results from 2020-2023 indicated PM2.5, PM10, NO_2, SO_2, and O_3 levels were steadily increasing while the CO levels were decreasing in Colombo. Further, Kandy showed higher average O_3 and CO levels than Colombo throughout the study period. The vehicular emission inventory revealed a clear differentiation in source contribution; light vehicles (cars, vans, and motorbikes) were the primary sources of CO, while light trucks and heavy-duty vehicles constituted the major sources of CO_2, NO_2, SO_2, and particulate matter. This research provides a scientifically grounded, localized emission inventory and trend analysis, delivering essential data for developing targeted traffic management interventions and evidence-based air quality mitigation policies.

Keywords: ambient air quality; urban areas; vehicular emissions

Waste Heat Recovery from the Banbury Mixer to Enhanced Biomass Drying Using Shell and Tube Heat Exchanger

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Abstract

The Banbury mixer produces significant waste heat due to mechanical shear and friction during rubber mixing, which is typically dissipated via water cooling systems and lost to the environment. This study proposes capturing this thermal energy through a shell and tube heat exchanger designed and simulated using Aspen Plus V14 and SolidWorks 2024 software. The recovered heat is then transferred to atmospheric air to dry biomass efficiently, replacing solar drying methods and enhancing combustion efficiency in biomass boilers. The approach aims to reduce energy waste, improve biomass drying consistency regardless of weather conditions, and lower greenhouse gas emissions by minimizing fossil fuel dependency. The design process involved theoretical calculations, simulation of heat exchanger geometry, and performance evaluation, focusing on optimizing heat transfer and pressure drops. A shell and tube heat exchanger following a BEM configuration and the hot water stream outlet temperature ranges between 130-170 ℃, while cold air stream is heated from 30 ℃ to 100-150 ℃. The heat exchanger features a 1.5 m tube length, 19.05 mm outer diameter tubes, triangular tube pitch, and segmental baffles with a 25% cut. Convective heat transfer coefficients were calculated as 124.44 W/m^2K (tube side) and 2161.17 W/m^2K (shell side). Theoretical calculation confirms effective thermal performance, which will be further validated through simulation in Aspen Plus V14 and mechanical design in SolidWorks 2024.

Keywords: waste heat recovery; Banbury mixer; biomass drying; energy efficiency; shell and tube heat exchanger

Food Security, Nutrition, and Processing Technology

Development and Analysis of Herbal Floral Wine from *Clitoria ternatea* (Butterfly Blue Pea)

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Abstract

The production of herbal floral wine using *Clitoria ternatea* (butterfly blue pea), which is renowned for its vibrant blue color and notable health benefits. It identifies that the modern dietary patterns often lack essential nutrients and phytochemicals, leading to increased risk of non-communicable diseases such as diabetes, obesity, and heart diseases. This research explores the potential of phytochemically rich beverages to fill that nutritional gap. The wine was developed through traditional fermentation techniques, utilizing *Saccharomyces cerevisiae* with sugar serving as a primary substrate. The formulation was enriched with butterfly blue pea flower extract and selected spices to enhance its sensory properties and functional value. Wine was aged for a 12-month period, and then physicochemical and microbial analyses were conducted for the characterization of the herbal floral wine. Wine produced recorded 13% alcohol by volume, a pH of 3.64±0.03, and a specific gravity of 0.984±0.03, which indicates that fermentation took place and was efficient. The total acidity of the wine was recorded at 4.5±0.04 g/L as tartaric acid. Antioxidant activity assessed using the DPPH assay yielded DPPH IC_{50} value at 0.32 mg/mL, which indicates a high radical scavenging capacity. Microbiological tests recorded an aerobic plate count of 4 CFU/mL and a yeast and mold count of less than 10 CFU/mL, which shows very good microbial safety. Overall, butterfly pea flower wine is rich in beneficial compounds, including anthocyanins, flavonoids, and polyphenols, bioactive compounds known for their antioxidant, anti-inflammatory, and disease-preventive properties. These findings show that butterfly blue pea wine is a phytochemically enriched, microbiologically safe fermented beverage for consumption, which presents a promising alternative within the growing market for health-oriented fermented drinks.

Keywords: alcoholic beverages; butterfly blue pea; flower wines; herbal wine

Assessment of Nutritional Composition of Green Leafy Vegetable *Pisonia grandis* in Sri Lanka

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Abstract

Green leafy vegetables (GLVs) play an important role in the Sri Lankan diet by providing both nutritional and health benefits. Although Sri Lanka is enriched with a diverse range of nutrition-rich GLVs, many of them are underutilized. *Pisonia grandis* is an evergreen tree, and its leaves have been proven to have many functional health benefits. Consequently, *P. grandis* leaves are immensely used in traditional herbal medicine. However, the nutritional value of *P. grandis* grown in Sri Lanka has barely been examined. Therefore, this current study aims to assess the nutritional profile of *P. grandis* in Sri Lanka. Collected *P. grandis* leaves were properly washed and dried at 45 ℃ to obtain a constant weight. Dried samples were ground to obtain the powder and moisture content, ash, crude protein, crude fat, crude fiber, and available carbohydrate contents and metabolizable energy of *P. grandis* were determined. Moisture content of fresh leaves and dehydrated powder was found as 79.82±1.03 g/ 100 g of fresh weight and 5.16 ±0.17 g/100 g of dry weight (DW), respectively. The ash content of *P. grandis* was 19.97 ±0.36 g/100 g of DW. Crude protein and crude fat content of leaves were 9.37±0.13 g/100 g DW and 11.20 ±0.67 g/100 g DW, respectively. Moreover, *P. grandis* was a good source of crude fiber (12.19±1.17 g/100 g DW). The carbohydrate and metabolizable energy of *P. grandis* were found as 42.11±1.05 g/100 g DW and 306.70±5.10 kcal/100 g DW, respectively. Overall, *P. grandis* is one of the nutrition-rich GLVs grown in Sri Lanka that can be used as an affordable and alternative food resource, although currently it shows less consumption.

Keywords: green leafy vegetables; nutritional value; nutrition security; *Pisonia grandis*

Formulation and Quality Evaluation of Gluten-free High-fiber Cookies using Finger Millet (*Eleusine coracana*) and Cassava (*Manihot esculenta*) Flour Blends

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Abstract

This study aims to develop a gluten-free cookie enriched with dietary fiber using cassava (*Manihot esculenta*) and finger millet (*Eleusine coracana*) as the main ingredients. The increasing demand for gluten-free products has been driven by the development of nutrient-enriched alternatives that replace traditional wheat flour-based products. Finger millet is considered a naturally gluten-free cereal, a rich source of fiber, antioxidants, and micronutrients, and it was subjected to the germination process to enhance its nutritional profile, while the incorporation of cassava flour contributed to desirable functional characteristics and maintained the gluten-free nature of the product. Cookies formulated with 100% wheat flour were considered the control (T1). Five different cookie formulations consisting of cassava flour and germinated finger millet flour in the ratios 100:00 (T2), 25:75 (T3), 50:50 (T4), and 75:25 (T5) was prepared. Two treatments were selected among the five formulations following the sensory evaluation to assess the proximate composition, including moisture, crude fiber, crude fat, crude protein, ash, and energy value. The best performing formulation identified through sensory evaluation and the control sample were chosen to facilitate a comparative analysis of nutritional composition. The physical properties, such as diameter, thickness, density, and spread ratio, were measured to assess the structural attributes. Sensory attributes such as taste, texture, color, aroma, and overall acceptability were assessed using a sensory evaluation conducted with 30 untrained panelists. The results demonstrated that T5 (cassava flour 75: malted millet flour 25) significantly increased crude fiber (36.66%), ash content (3.07%), and moisture content (1.77%), while crude fat (20.17%) and crude protein (6.24%) contents were significantly reduced. The optimized formulation of the cookie demonstrated the potential as a functional, gluten-free product suitable for individuals with gluten intolerance. This study demonstrates that incorporating cassava flour and germinated finger millet flour into cookie formulations can significantly enhance both nutritional quality and consumer preference compared to conventional wheat-based cookies.

Keywords: cassava; dietary fiber; finger millet; functional food; gluten-free cookies

Impact of Freeze-drying and Oven-drying on Antioxidant and Antioxidant Activity of Selected Medicinal Herbs

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Abstract

Drying is a critical preservation process that can markedly influence the bioactive profile of medicinal herbs. This study evaluated the impact of freeze-drying and oven-drying on the total phenolic content (TPC) and antioxidant activity of ethanolic extracts (EE) from *Asparagus falcatus* roots, *Withania somnifera* roots, and *Centella asiatica* leaves. Plant materials were dried using both methods and then extracted with ethanol. TPC was quantified using the Folin-Ciocalteu method, and antioxidant activity was assessed through 2,2-diphenyl-1-picrylhdrzyl (DPPH) and 2′-azino-bis-3-ethylbenzthiazoline-6-sulphonic (ABTS) radical scavenging assays (05-95 mg/mL). The results showed that, freeze-drying markedly enhanced the retention of bioactive compounds compared to oven-drying in all three medicinal plants studied compared to oven-dried samples. In *C. asiatica*, freeze-dried samples showed significantly high TPC (237.71±2.54 mg GAE/g DW), and the highest antioxidant activity via DPPH IC_{50} (36.74±2.23µg/mL), and ABTS (85.41±0.79%) radical scavenging activities than oven-dried *C. asiatica*, which recorded a TPC of 139.75±10.96 mg GAE/g DW, an IC_{50} of 41.02±1.06 µg/mL, and ABTS activity of 75.95±0.38% ($p<0.05$). Similarly, freeze-dried *W. somnifera* exhibited significantly higher bioactive properties, with a TPC of 178.60±1.00 mg GAE/g DW, strong antioxidant activity (IC_{50}: 43.34±2.68 µg/mL), and ABTS activity (79.40±0.38%) compared to the oven-dried form (TPC: 107.86±1.66 mg GAE/g DW, IC_{50}: 51.71±0.82 µg/mL, ABTS: 64.46±3.20%, $p<0.05$). Among the three plants, *A. falcatus* showed the lowest overall values, compared to its freeze-dried samples (TPC: 64.75±4.18 mg GAE/g DW, IC_{50}: 50.63±0.88 µg/mL, ABTS: 61.93±1.69%) still outperformed the oven-dried (TPC: 42.13±5.56 mg GAE/g DW, IC_{50}: 60.76±0.42 µg/mL, ABTS: 52.61±2.38%, $p<0.05$). Freeze-dried *C. asiatica* had the significantly highest bioactive and antioxidant activity compared to the *W. somnifera* and *A. falcatus* ($p<0.05$). The superior performance of freeze-dried samples may be attributed to the drying process, which minimizes thermal degradation and preserves heat-sensitive phenolic compounds and antioxidant components, thereby enhancing overall antioxidant potential.

Keywords: medicinal plants; antioxidants; phenolics; freeze-drying; oven-drying

Development and Quality Evaluation of Cowpea (*Vigna catjang*), Lasia (*Lasia spinosa*), and Young Jackfruit (*Artocarpus heterophyllus*) Incorporated Plant-based Meat Analogues

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Abstract

Meat analogues are designed to mimic the taste, texture, and nutritional profile of meat. Despite the increasing demand for plant-based meat analogues, research on utilizing locally available plant resources for meat analogue production remains limited in Sri Lanka. Therefore, this study aimed to develop a novel plant-based meat analogue incorporating cowpea (*Vigna catjang*), lasia (*Lasia spinosa*) root, and young jackfruit (*Artocarpus heterophyllus*) and to evaluate its physicochemical, nutritional, and antioxidant properties. The samples were formulated using Taguchi's L9 Orthogonal Array incorporating three factors at three levels: lasia root percentage (20, 25, and 30%), young jackfruit percentage (10, 15, and 20%), and steaming time (10, 15, and 20 minutes). Based on the experimental design, nine formulations were developed and evaluated to select the best formulation. The formulation, containing 30% lasia, 10% young jackfruit, 15% cowpea, and steamed for 15 minutes, was selected based on its protein content (9.5%), firmness (2.6 N), cooking yield (94.4%), cooking loss (0.1%), and the liquid holding capacity (94.4%). The quality of the selected formulation was assessed through its physicochemical properties, including pH (6.3), color characteristics (L:44.9, a*:5.7, b*:29.4), and water activity (0.99). Microbiological analysis confirmed the safety of the product with a total plate count less than 105 CFU/g, a yeast and mold count less than 103 CFU/g, and no detectable coliforms. The developed meat analogue contained 57.5% moisture, 22.6% carbohydrates, 9.5% protein, 8.3% fat, 2.2% ash, and 0.02% crude fiber. total phenolic content (432.3±0.5 mg gallic acid equivalents/100 g), total flavonoid content (165.5±0.5 mg Quercetin equivalents/100 g), and ability to scavenge DPPH radicals (227.6±1.0 mg Trolox equivalents/100 g) indicated the antioxidant properties of the developed meat analogue. This study indicated the potential of using lasia root, young jackfruit, and cowpea in successfully developing meat analogues.

Keywords: cowpea; lasia root; meat analogues; plant-based products; young jackfruit

Advances in Diagnostic Approaches for Hemoparasitic Diseases in Sri Lankan Cattle: Trends, Prevalence, and Challenges

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Abstract

Tick-borne hemoparasitic diseases, including theileriosis, babesiosis, and anaplasmosis, continue to be significant constraints to cattle health and dairy productivity in Sri Lanka. These diseases are mainly transmitted by ixodid ticks, especially *Rhipicephalus microplus*, which flourish in the country's tropical climate. The aim of this review is to synthesize current knowledge on the distribution, diagnosis, and impact of tick-borne hemoparasites in Sri Lankan cattle and to recommend practical strategies for their control. The primary objectives are to assess the prevalence of key pathogens (*Theileria orientalis*, *Babesia bigemina*, and *Anaplasma marginale*), evaluate current diagnostic approaches, and identify gaps in control measures. This review consolidates findings from peer-reviewed studies, surveillance reports, and national veterinary data published between 2011 and 2023. Papers were selected based on their relevance to human or livestock brucellosis, with priority given to studies reporting seroprevalence, diagnostic methods, and risk factors. Results indicate a high prevalence of these hemoparasites, particularly among crossbred and exotic dairy cattle in endemic regions, with frequent cases of mixed infections. Indigenous breeds exhibit notable resilience, showing lower morbidity and mortality rates, suggesting potential for genetic resistance breeding programs. Diagnostic practices have evolved from conventional Giemsa-stained blood smears to advanced molecular techniques such as PCR, which offer greater sensitivity, especially for subclinical infections. Despite these advancements, disease control remains inadequate due to challenges such as widespread tick resistance to acaricides, absence of commercial vaccines, and poor farm-level biosecurity. The economic consequences include reduced milk yield, increased treatment costs, and compromised reproductive performance. Based on these findings, effective management of hemoparasitic diseases in Sri Lanka may benefit from integrated technological approaches. These include the adoption of rapid and field-applicable diagnostic tools, implementation of precision tick-control techniques, utilization of resistant livestock breeds guided by breeding programs, and development of digital surveillance systems to monitor disease trends and support farmer decision-making. Moreover, coordinated efforts between veterinary authorities, researchers, and farmers are essential to reduce disease incidence and improve livestock productivity. These science-based, locally adapted interventions can protect cattle health, enhance rural incomes, and contribute to the resilience of the national dairy sector.

Keywords: hemoparasitic disease; *Rhipicephalus microplus*; *Babesia bigemina*; *Anaplasma marginale*

Chitin Nanofiber Reinforced Linear Low-density Polyethylene Composites for Sustainable Food Packaging Applications

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Abstract

The environmental burden of conventional plastics and concerns over food safety have prompted the development of sustainable polymer composites with functional properties. This study developed chitin nanofiber (CNF)-reinforced linear low-density polyethylene (LLDPE) composites using maleic anhydride-grafted LLDPE (3 wt%) as a compatibilizer to overcome fiber–matrix incompatibility. CNFs derived from crab shells (seafood waste) are biodegradable reinforcements with known antimicrobial potential. LLDPE is widely used in packaging due to its excellent mechanical strength and processability. CNFs were incorporated into LLDPE at 2-10 wt% loadings via melt blending and compression molding. To address the compatibility challenges between hydrophilic CNF and hydrophobic LLDPE, maleic anhydride-grafted LLDPE (MA-g-LLDPE) was employed as a compatibilizer (3 wt%). The composites were evaluated for mechanical, thermal, morphological, and antibacterial performance. FTIR confirmed the α-chitin structure and effective compatibilization. Tensile strength increased by 10.3% at 4 wt% CNF (10.7 MPa vs. 9.7 MPa for neat LLDPE), while compressive strength peaked at 8 wt% (24.1 MPa, +14.8%). Hardness progressively improved to 47.8 Shore D (+9.2%), and TGA indicated a slight enhancement in thermal stability with ~1-2 % char residue at 600 °C. SEM revealed uniform fiber dispersion at low loadings and minor agglomeration at higher contents. However, no inhibition zones were observed in agar diffusion tests, likely due to restricted CNF mobility within the hydrophobic matrix, hindering migration into the test medium despite potential contact-based antibacterial action, suggesting the need for contact-based antibacterial assays (e.g., ISO 22196). Despite the lack of visible diffusion-based antibacterial activity, the enhanced mechanical performance and eco-friendliness suggests that CNF/LLDPE composites hold promise as partially biodegradable food packaging materials with potential antibacterial function under direct-contact conditions.

Keywords: antibacterial packaging; biodegradable composites; chitin nanofibers; LLDPE

Process Optimization, Microbiological and Sensory Quality Evaluation of Mozzarella Cheese from Different Milk Types for its End Use Application

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Abstract

Mozzarella is a soft, white, un-ripened cheese belonging to the *Pasta filata* family, widely valued in pizza production. Various types of mozzarella are produced from buffalo, cow, and goat milk. It is derived from the drainage of liquid following the coagulation of milk. In this study, the coagulation process was enhanced by calcium chloride (0.03% w/w). Skim milk powder was added at 3% (w/w) to improve texture and consistency. Rennet (0.003% w/w) and starter culture (0.031% w/v) were added as other ingredients. The curd was skillfully stretched in hot water to develop a smooth, elastic texture of Mozzarella cheese. Cow milk and goat milk were mixed 6:4 in ratio. The present study was focused on process optimization of premium cow milk mozzarella cheese (CMMC), goat milk mozzarella cheese (GMMC) and mixed milk mozzarella cheese (MMMC), and check the yield, microbial quality, and physicochemical properties. Meanwhile, the study aimed to identify the most suitable milk or combination type for subsequent product development. The cheeses were subjected to analysis throughout storage temperature of 4 °C and intervals of 07 days. MMMC exhibited the highest overall acceptance sensory score. MMMC (11.5%) and CMMC (13.5%) were demonstrated the highest yield than GMMC (10.4%). Fat level decreased with increasing storage days, with a significant difference ($p<0.05$). Moisture content of MMMC (44.77%) was significantly lower from CMMC (46.75%) and GMMC (44.77%). Coliform count of MMMC was significantly ($p<0.05$) lower than CMMC and GMMC. Mozzarella cheese preparation from goat milk is not recommended. Meanwhile, combining goat milk results in a high nutritional value and health benefits. Manufacture of MMMC is highly recommended for industrial scale. Meanwhile, skim milk powder improves consistency and reduces fat. This study addresses increasing the cow milk proportion in MMMC led to denser curd and lower moisture content compared to pure GMMC and CMMC, as notable encouragement in dairy industries.

Keywords: cow milk; goat milk; mixed cow and goat milk; mozzarella cheese; microbial analysis

Comparative Study on the Effect of Ultrasound-assisted *Annona muricata* Seed and Peel Extract on Oxidative Stability of Biscuits

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Abstract

As the food industry shifts toward natural antioxidants, this study focused on the effect of phenolic extracts from *Annona muricata* seed (ASE) and peel (APE) compared to synthetic antioxidants on the oxidative stability of biscuits. This study investigated the phenolic profile, antioxidant activity, and *in vitro* cytotoxicity of extracts and evaluated their effect on the shelf-life of biscuits. Phenolic antioxidants were extracted using 100% ethyl acetate by ultrasound-assisted extraction. Total phenolic content (TPC) and total flavonoid content (TFC) were determined using Folin-Ciocalteu and Aluminum Chloride methods, respectively. Phenolic compounds were identified by high-performance liquid chromatography (HPLC). Antioxidant activity was determined using ABTS•+ assay and compared with the synthetic antioxidant butylated hydroxytoluene (BHT). Cytotoxicity was assessed on Caco-2 cells exposed to 50-800 µg/mL extract concentrations at 24, 48, and 72 hours of incubation. Furthermore, biscuits with antioxidants (200 mg/kg) were tested for oxidative stability, microbial shelf-life, and sensory quality over 90 days of storage at 25 °C. The results indicated that ASE showed TPC (g GAE/kg) and TFC (g QE/kg) of 7±0 and 11±1, while APE had 19±1 and 9±0, respectively. HPLC identified p-coumaric, chlorogenic, syringic acids in ASE and rutin, chlorogenic, vanillic acids in APE. ABTS•+ assay showed lower IC_{50} (µg/mL) for ASE (40±0) and APE (41±1) than BHT (65±1). In cytotoxicity assessment on Caco-2 cells, ASE (542±1) and APE (728±2) exhibited higher IC_{50} than BHT (341±2). Biscuits with ASE and APE maintained acceptable peroxide and thiobarbaturic acid reactive substances for 90 days, unlike control without antioxidants (56 days) and BHT-added biscuits (70 days). ASE and APE-added biscuits showed safe microbial counts throughout storage, while APE-added biscuits showed the highest sensory scores over the storage. Findings highlight ASE and APE as promising natural alternatives to synthetic antioxidants, offering strong antioxidant activity, low toxicity, and extended shelf-life.

Keywords: antioxidant activity; cytotoxicity; microbial shelf-life; oxidative stability; sensory quality

Utilization of Processing Waste of Pineapple for Cider Production Enriched with Cinnamon and Cardamom Flavors

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Abstract

Pineapple (*Ananas comosus* L. Merr.*)* is one of the prominent, non-climacteric fruits used in the food processing industry. In processing sites, approximately 40 to 50% of pineapple waste is generated as peel and middle core. The pineapple waste is rich in antioxidants, fiber, and fermentable sugar. The study focused on the production of pineapple peel cider for commercialization as a sustainable waste utilization solution. Mature pineapple peel (Variety: Mauritius) obtained from a selected field was used for the study. Alcoholic fermentation was done at room temperature (30±1 ℃) for nine pineapple peel extract samples consisting of three different sugars (150, 175, and 200 g/L) and yeast (1, 1.5, and 2 g/L) concentrations. Obtained cider samples were evaluated for alcohol content (w/v), pH, and total soluble solids (TSS) for seven days. Fermentation inhibition was carried out as nine indirect heat treatments (as separate batches) with three different temperatures (60, 70, and 80 ℃) and time combinations (10, 15, and 20 minutes). The resulting cider samples were studied over 10 days to evaluate changes in alcoholic content (w/v), pH, and TSS content. The study proves that an increase in yeast and sugar added to cider significantly ($p<0.05$) increases the percentage of alcohol produced. According to the results, 150 g/L sugar concentration over 1 g/L yeast concentration was selected as the best combination, with 4% alcohol content (w/v), 4.14±0.037 pH, and 12.43±0.15 TSS values. The values observed were in close agreement with the standard for cider. Complete yeast inactivation was observed at 80 ℃ for 25 minutes heat treatment with the lowest variation of alcohol content, pH, and TSS over time. This study proves that the processing waste of pineapple can effectively be used as a potential raw material for cider production and a sustainable solution for waste accumulation in the fruit processing industry.

Keyword: pineapple peel; fermentation inhibition; cider; waste accumulation

Formulation of a Nutrient-enriched, Ready-to-eat Vegan Egg Substitute

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Abstract

The global demand for vegan products has been steadily increasing due to rising awareness of health benefits, animal welfare, and environmental sustainability. Vegans follow a lifestyle that excludes all animal-derived products. This study aimed to formulate and evaluate the quality of a ready-to-eat vegan egg with enhanced nutritional value, sensory quality, and consumer acceptability. The vegan egg white was primarily prepared using tofu and mung beans, while the vegan egg yolk was formulated using pumpkin and *Dioscorea alata* (hingurala yam) as the main plant-based ingredients. Additional ingredients, including agar-agar powder, nutritional yeast, aquafaba, turmeric powder, black salt, and olive oil, were incorporated to enhance flavor, color, and sensory appeal. Sensory evaluations were conducted using a 5-point hedonic scale by a semi-trained panel of 30 members for a series of egg white formulations (EWF2) and egg yolk formulations (EYF4). The optimal ratios were identified as tofu 80 g: mung beans 20 g for the egg white and pumpkin 60 g: hingurala yam 60 g for the egg yolk based on the highest scores for appearance, texture, aroma, taste, and overall acceptability. Proximate analysis revealed that EWF4 contained significantly higher crude protein (39.87%) content compared to conventional egg white, along with substantial amounts of crude fiber (30.72%), whereas conventional eggs contain no dietary fiber. EYF3 (pumpkin 60 g: hingurala yam 40 g) demonstrated significantly lower crude fat content (1.29%) than conventional egg yolk. Microbial analysis indicated very low aerobic plate counts (<40 CFU/g) and yeast and mold counts (<10 CFU/g), confirming hygienic processing. Samples stored under refrigerated conditions (4±1 °C) for 7 days, even without the use of preservatives, maintained acceptable microbial quality. Overall, the developed vegan egg provides a sustainable and ethical substitute for traditional chicken eggs, aligning with the growing demand for healthier and eco-friendly food options.

Keywords: ready to eat; vegan egg; vegan alternative; dietary fiber

Probiotic and Antioxidant Properties of *Saccharomyces* and Non-*Saccharomyces* Yeast Strains Isolated from Sri Lankan Grapes (*Vitis vinifera*)

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Abstract

Grape skin harbors a diverse community of microorganisms, including various *Saccharomyces* and non-*Saccharomyces* species that increase the sensory qualities of wine. This study aims to determine the probiotic and antioxidant potential of yeast strains isolated from Sri Lankan grapes, *Hanseniaspora uvarum* JF3-T1N, *Hanseniaspora opuntiae* J1Y-T1, *Starmerella bacillaris* WMP4-T4, and *Saccharomyces boulardii* JSB-T2. The probiotic potential was assessed by evaluating the yeast strains' tolerance to acidic pH *(*2.0 and 3.0), bile salts *(*0.3% and 0.5% (w/v)), NaCl *(*3.0% and 6.0% (w/v)), phenol *(*0.4% (w/v)), and survival rate in artificial gastrointestinal conditions. Antioxidant activity was evaluated using 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assay, 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, ferric reducing antioxidant power assay, and total phenolic content (TPC) assay. Among the tested yeast strains, *S. boulardii* JSB-T2 exhibited the highest tolerance to acidic pH, bile salts, NaCl, phenol, and different temperatures. It also demonstrated strong tolerance to gastrointestinal conditions, maintaining survival rates of 94.10±1.07% in artificial saliva, 89.89±1.09% in simulated gastric juice, and 85.95±0.86% in simulated intestinal juice. All yeast strains showed strong cell surface hydrophobicity and auto-aggregation properties, indicating their ability to colonize the gastrointestinal tract. *S. boulardii* JSB-T2 also showed moderate antibacterial activity against foodborne pathogens and some tolerance to itraconazole, fluconazole, and terbinafine hydrochloride antifungal agents. *S. bacillaris* WMP4-T4 demonstrated the strongest antioxidant potential with a TPC value of 0.0115±0.0005 mg/mL and ABTS radical scavenging activity of 55.49±0.32% while *S. boulardii* JSB-T2 exhibited the highest activity in the DPPH assay with 22.02±0.41% scavenging activity. Among the strains tested, *S. boulardii* JSB-T2 showed strong probiotic potential, offering promising applications in functional food products.

Keywords: *Saccharomyces boulardii*; *Starmerella bacillaris*; probiotic potential; antioxidant activity; simulated gastrointestinal conditions

Formulation and Quality Evaluation of Mango Incorporated Jelly Crystals from Red Seaweed (*Kappaphycus alvarezii*)

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Abstract

Kappaphycus alvarezii is an underutilized red seaweed found in the coastal region of Mannar, Sri Lanka, known for its high carrageenan polysaccharide content, making it suitable to develop a sustainable, plant-based alternative to synthetic and animal-derived gelling agents used in jelly production. The main objectives were to extract and characterize carrageenan from *K. alvarezii*, formulate mango-based jelly crystals incorporating the extracted carrageenan, to select the best drying method (dehydration, vacuum drying, and heat pump drying) for jelly crystal formation, and to characterize the resulting jelly crystals. Carrageenan was extracted using hot water treatment at 80 °C for 20 minutes. *Karthakolomban* mango pulp was incorporated into the gel to enhance the flavor and nutritional value, and citric acid was used to adjust the acidity. A Taguchi L9 orthogonal array design was employed to formulate and optimize various combinations of carrageenan gel, mango pulp, and citric acid. The resulting formulations were evaluated for their sensory attributes, physicochemical properties, and microbial quality parameters. Based on the sensory evaluation with 10 trained sensory panelists using a seven-point hedonic scale, the formulation containing 29.7% of mango pulp, 69.3% of carrageenan gel (semi-solid), and 0.99% of citric acid was found to be the most acceptable. Considering factors such as drying yield, drying time, color, and product handling efficiency, heat pump drying was determined to be the most suitable drying method for mango jelly. The final product was prepared by thoroughly mixing powdered sugar with dried jelly crystals (2:1 ratio). Mango-flavored jelly crystals were rich in carbohydrates (93.2 ± 0.2%), with minimal crude fat (0.16±0.02%) and crude protein content (2.5±0.1%), making it a low-calorie dessert option. The shelf life of the final product was evaluated to be over 90 days when packaged using triple-laminated aluminum. These jelly crystals offer a sustainable and vegan-friendly dessert with promising commercial applications, utilizing locally sourced seaweed and tropical fruits as novel ingredients.

Keywords: carrageenan; jelly crystals; *Kappaphycus alvarezii*; red seaweed

Development of Plant-based Spray in Controlling Anthracnose Disease caused by *Colletotrichum musae* in Embul Banana (*Musa acuminata*–AAB)

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Abstract

Anthracnose is a severe postharvest disease of Embul banana (*Musa acuminata*, AAB group). Essential oils and various plant extracts were investigated and developed into a ready-to-use formulation to control anthracnose disease and reduce the use of synthetic fungicides. The causal organism isolated from the diseased bananas was identified as *Colletotrichum musae* through morphological characterization. The minimum inhibitory concentrations (MIC) at 1 MIC, 2 MIC, 4 MIC, and 8 MIC of nine different botanicals including clove bud oil, cinnamon leaf oil, cinnamon bark oil, nutmeg oil, black pepper oil, banana peel extract, and leaf extracts of papaya, soursop, and bael were determined and tested *in vitro* against the radial mycelial growth of *C. musae*. Among them, clove bud oil, cinnamon bark oil, and papaya leaf extract demonstrated significant growth inhibition. Four formulations were developed by adjusting the concentrations of clove bud oil, cinnamon bark oil, and papaya leaf extract, using ethanol for dissolving purposes, Tween 80 as an emulsifier, and distilled water as the carrier medium. In *in vivo* experiments, developed formulations were sprayed on bananas, while comparisons were made with fruits treated with distilled water and untreated fruits. The optimal formulation comprised clove bud oil, cinnamon bark oil, papaya leaf extract, ethanol, Tween 80, and distilled water in a ratio of 1:1:1:6:4:87, respectively. The formulated product did not negatively affect the physicochemical properties of the banana fruits. Sensory evaluation revealed no significant differences in color and aroma between the treated and the control samples, whereas texture and taste differed significantly. The shelf life of treated bananas was estimated to be 8 days. The formulated product exhibited a shelf life of over three months. This study demonstrated that the developed plant-based formulation effectively controls anthracnose in Embul bananas.

Keywords: essential oils; plant extracts; antifungal activity; postharvest management

Development and Quality Evaluation of Palmyrah Fruit Pulp-based Biscuits

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Abstract

Palmyrah (*Borassus flabellifer*) is an underutilized fruit in Sri Lanka with high nutritional potential, particularly dietary fiber, carotenoids, and antioxidants. This study aimed to develop and evaluate semi-sweet biscuits incorporating debittered black-skinned palmyrah fruit pulp to improve nutritional value, functionality, and consumer acceptability. The pulp was debittered by adjusting the pH to 3.8 with concentrated citric acid, followed by heating at 90 °C for 20 seconds, and stored under refrigeration until use. A Taguchi L9 orthogonal array design was applied to create nine biscuit formulations with varying pulp incorporation (20, 25, and 30%), milk powder (0, 5, and 10%), and baking temperature (175, 180, and 185 °C). Moisture content analysis identified six formulations meeting the Sri Lanka Standards (SLS 251:2010a) limit (<4%) for microbial stability. Sensory evaluation with 30 semi-trained panelists using a 7-point hedonic scale (1=dislike very much; 7=like very much) selected the optimal formulation (25% pulp, 5% milk powder, 180 °C) based on the overall acceptability. The optimized biscuits were packed in laminated polyethylene pouches and compared with the control biscuit (100% wheat flour). When compared, no significant differences were observed, including color, odor, appearance, taste, and overall acceptability. Physicochemical analysis revealed that the experimental biscuit had a slightly softer texture, desirable spread ratio (10.11±0.63), reduced baking loss (28.10%), and lower pH (5.72±0.03). Proximate composition showed significantly higher fat (10.41±0.01%) and crude fiber content (0.45±0.01%), enhancing its functional value, while protein and carbohydrate levels remained within standard ranges. Microbial analysis over 28 days demonstrated stable total plate count and reduced yeast and mold growth in the experimental biscuit compared to the control. The results demonstrate the feasibility of incorporating palmyrah pulp into bakery products to produce value-added, shelf-stable functional foods and promote local agricultural utilization.

Keywords: functional biscuit; palmyrah pulp; proximate composition; sensory evaluation; shelf-life analysis

Development of a Fruit Leather from Underutilized Local Fruit: Tamarind (*Tamarindus indica*)

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Abstract

The potential of underutilized tamarind (*Tamarindus indica*) in value-added food product development remains largely unexploited in Sri Lanka. This research aimed to develop tamarind fruit leather and analyze the physicochemical, sensory, and nutritional properties of the final product. Tamarind pulp was extracted from ripened fruits and combined at varying proportions to produce six formulations. Three levels of tamarind, 10, 15, and 20 weight percentages, and two ratios of tamarind to sweetener (1:1, 1:2) were tested, while keeping the only stabilizer a constant (0.004%), undisclosed plant-sourced ingredient in relative amounts to reach 100% weight proportion. The formulations were dried using a convective electric oven at 90 °C for 3 hours to achieve the desired moisture content (7.7±0.2% wb). Physicochemical properties, including pH, total soluble solids (TSS), and color, were analyzed. Sensory evaluation was conducted by a trained panel using a 9-point hedonic scale to assess appearance, color, aroma, taste, flavor, mouthfeel, and overall acceptability. The results demonstrated that tamarind pulp's low pH (2.66±0.04), moderate moisture (20.83±0.4%), and high TSS (27.17±0.44 °Brix) make it ideal for fruit leather preparation. Formulation (T6) with the highest proportion of tamarind (20%) and tamarind: sweetener ratio (1:2), achieved the best sensory scores, particularly for taste (7.0) and overall acceptability (7.58). Proximate analysis of T6 revealed its high carbohydrate content (84.35±0.22%) and energy density (350.62±0.23 kcal/100 g), making it a nutritious, low-fat (0.2±0.01 g), high fiber (2.35±0.02 g) snack. The study concludes that tamarind fruit leather is a viable product for sustainable food innovation, offering a nutritious and shelf-stable alternative to sugar-rich confectionery. Further research is undertaken to explore flavor enhancement, to conduct shelf-life studies under varying storage conditions, and to develop eco-friendly packaging to enhance consumer appeal and ensure product freshness.

Keywords: underutilized fruits; nutritional properties; physicochemical properties; sensory evaluation; fruit leather

Formulation and Quality Assessment of Ginger-enriched Goat Milk Yogurt

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Abstract

Goat milk is a nutrient-rich base for functional dairy products, but its characteristic "goaty" flavor often limits consumer appeal. This study evaluated the effects of incorporating ginger (*Zingiber officinale*) on the physicochemical, nutritional, and sensory properties of goat milk yogurt. Yogurt was prepared by incorporating 1-5% (w/w) ginger powder, calculated relative to the weight of milk, along with a control (without ginger). The samples were analyzed for physicochemical properties such as pH, titratable acidity, and syneresis, nutritional quality, including ash and moisture content, microbial quality, and sensory acceptance over three weeks of refrigerated storage. The results demonstrated that ginger addition had a significant effect on yogurt quality ($p<0.05$). Physicochemical analysis showed that pH decreased over storage, with the 4% sample reaching the significantly highest titratable acidity (0.88±0.00%) by week three ($p<0.05$). Correspondingly, syneresis values over the storage period were 7.15±0.00% for the 2% ginger-fortified yogurt and 7.73±0.00% for the 3% ginger-fortified yogurt. Nutritional analysis showed that ash content increased with higher ginger concentrations, which may be attributed to the mineral content of ginger. Throughout the three-week storage period, the moisture content remained significantly high in the 2% ginger formulation (88.60±0.28%, $p<0.05$). *Streptococcus thermophilus* exhibited a dose-dependent increase during the first week, with the highest counts observed in the 4% ginger treatment. *Lactobacillus* spp. showed minimal variation during the early storage period but increased significantly by week three, particularly in the 4% ginger treatment ($p<0.05$). Sensory evaluation identified 2-4% ginger addition as optimal for masking undesirable "goaty" flavor. The 2% sample achieved the greatest overall acceptability and a balanced taste and texture profile. Overall, moderate ginger levels (2-3%) enhanced the nutritional and sensory qualities of goat milk yogurt without compromising product stability, indicating its potential as a naturally flavored, value-added dairy product.

Keywords: goat-milk; ginger; physiochemical; microbial; sensory evaluation

Development of Soap Nut (*Sapindus trifoliatus*) Based Coating to Extend the Shelf Life of Mango Fruit

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Abstract

Mangoes are economically and nutritionally important tropical fruits, but are highly perishable and prone to postharvest diseases, particularly anthracnose caused by *Colletotrichum gloeosporioides*. In this study, a biodegradable and edible coating incorporating soap nut (*Sapindus trifoliatus*) extract was developed to enhance the shelf life and quality of mangoes during storage. The research was conducted in two main phases. First, the antifungal activity of soap nut extract was evaluated *in vitro* at concentrations of 15, 20, and 25 mg/mL. The 25 mg/mL extract showed the highest inhibition of fungal growth (84.4%) and was selected for coating formulation. In the second phase, mangoes were coated with three different formulations: T1-pectin, beeswax, Tween 20, and glycerol; T2-T1 with 25 mg/mL soap nut extract; and T3-T1 with 50 mg/mL soap nut extract. Fruits were stored under ambient conditions (28-30 °C, 55-60% RH) for 12 days and evaluated for physiological and biochemical changes. The T3 coating significantly minimized weight loss, maintained fruit firmness, and preserved pulp pH, titratable acidity, and total soluble solids. Furthermore, it exhibited the lowest disease incidence (50%) compared to 75% in the control. The synergistic effect of pectin, beeswax, and soap nut extract contributed to reduced respiration rate and microbial growth, thereby improving fruit quality and shelf life. This plant-based coating offers a natural, eco-friendly alternative to synthetic fungicides, aligning with sustainable postharvest management practices for tropical fruit preservation.

Keywords: mango; soap nut; edible coating; anthracnose; shelf life extension

Development of a Natural Jelly Drink from Upcycled Passion Fruit (*Passiflora edulis*) Peel Waste

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Abstract

The development of functional beverages from upcycled agro-industrial waste offers a sustainable approach to enhancing health while minimizing environmental burden. This study aimed to formulate a nutraceutical jelly drink using upcycled passion fruit (*Passiflora edulis*) peel, an underutilized by-product rich in pectin, dietary fiber, and antioxidants, known for its potential benefits to digestive health. Dehydrated passion fruit peel powder, produced from peels discarded by the food processing industry, was incorporated into the formulated product. Five jelly drink formulations were prepared by varying the concentration of passion fruit peel for the increased pectin and dietary fiber content. A 30-member semi-trained sensory panel evaluated the samples based on sensory attributes: color, taste, texture, aroma, and overall acceptability to identify the most preferred formulation. The best-performing formulation (T3) containing 15 g passion fruit peel extract, in its dry powder form, exhibited a moisture content of, 12% and the ready-to-drink beverage recorded a pH of 5.37±0.06 and a brix value of 13.0±0.2°. Sensory evaluation revealed a significantly higher preference for this formulation, achieving mean scores of 4.33±0.66 for taste, 4.13±0.68 for mouthfeel, 4.00±0.64 for appearance, 4.13±0.68 for aroma and 4.27±0.64 for overall acceptability on a 5-point hedonic scale. The findings demonstrate that passion fruit peel can be effectively incorporated as a key ingredient in the development of nutraceutical jelly drinks and the potential of passion fruit peel as a sustainable, plant-based alternative to synthetic ingredients used in commercial jelly drinks. This innovation promotes environmental sustainability by transforming waste into a valuable product while also appealing to vegan and health-conscious consumers. Comprehensive nutritional analysis is recommended to confirm its health-promoting properties.

Keywords: digestive health; nutraceutical; passion fruit peel; upcycling

Impact of Blanching Techniques on Saponin Content and Quality Parameters in Dehydrated and Brine-Preserved Turkey Berries (*Solanum torvum* Sw.)

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Abstract

The study aimed at determining changes in saponin content and related quality parameters in dehydrated and brine-preserved berries of *Solanum torvum* Sw. (TB), after blanching pretreatment. TB were harvested, cleaned, and blanched by three techniques, namely water, microwave (95±2 °C), and steam for three durations (one, three, and five minutes). Lightness (L) of color, pH, saponin, and alkaloid contents were analyzed. The three highest saponin-yielding techniques were selected by analyzing data with one-way ANOVA and Tukey's pairwise mean comparison in Minitab 17.1. TB were blanched according to the best selected techniques, and they were subjected to hot air dehydration (10 hours at 50 °C) and preservation in acidified brine (5% salinity and 3.5 pH). Water, steam, and microwave blanching for five minutes resulted in significantly the highest ($p<0.05$) saponin contents, 0.27±0.02%, 0.24±0.02% and 0.26±0.02% respectively, amongst the three durations experimented. Values were not significantly different compared to those of non-blanched fresh berries (0.24±0.02%). Blanching in water and steam for five minutes significantly reduced alkaloid content, being 0.07±0.01% and 0.04±0.00% respectively. Fresh TB showed 0.12±0.01% alkaloid content. Post-blanching preservation in acidified brine or hot-air dehydration reduced saponin yield, however, losses were higher upon processing without blanching. To conclude, blanching in steam for five minutes will yield the highest saponin content and lowest alkaloid content, along with the best lightness of color, when preserved in acidified brine (0.21±0.02 % saponins, 0.06±0.01% alkaloids, L=59.14±1.73, pH=3.98±0.03) or hot-air dehydrated (0.17±0.04% saponins, 0.02±0.00 alkaloids, L=44.75±1.02, pH=5.45±0.04). Turkey berries which are preserved by brining or dehydration for later extraction of saponins, should be blanched to minimize saponin losses.

Keywords: alkaloids; blanching; brine preservation; saponins; *Solanum torvum*

Study on Storage Stability of Dehydrated Pumpkin (*Cucurbita maxima*) under Selected Packaging Materials

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Abstract

Pumpkin (*Cucurbita maxima*) is widely cultivated in Sri Lanka, yet over 20% of the harvest is lost annually due to poor handling and inadequate storage. Dehydration is an effective method to reduce losses and extend the shelf life of pumpkin. In this study, the storage stability of diced and dehydrated pumpkin was tested under four different packaging materials: 150-gauge LDPE, 250-gauge LDPE, vacuum-sealed 90-gauge LDPP, and laminated Kraft paper. The diced dehydrated pumpkin provides better color preservation and facilitates further processing upon use. Mature fruits (variety: ANK Ruhunu) were cut into 0.75 cm^3 cubes and convectively dehydrated to 6.0% (wb) moisture, and packaged in four materials in replicates needed for shelf-life testing. The packed samples were stored under ambient conditions (26.5±1.0 °C temperature and 80±5% relative humidity). Physicochemical properties, including moisture content, color, and rehydration ratio, and microbial safety were evaluated bi-weekly. Vacuum-sealed LDPP provides the best protection, maintaining color, rehydration, and microbial safety throughout storage. Laminated Kraft paper also performed well, but absorbed moisture gradually. Both materials are suitable for extended storage; however, the high cost limits their use. Kraft paper maintained microbial safety for up to eight weeks, while LDPE showed contamination after six weeks of storage. Packaging material significantly affected color retention and rehydration ($p<0.05$). Vacuum-sealed LDPP showed minimal color change, with ΔE reducing from 62 to 57, indicating excellent color stability, while 150-gauge LDPE showed major degradation, with ΔE decreasing from 60 to 46. LDPP had the highest rehydration ratio (3.76). These findings provide practical storage timelines for different packaging options, supporting quality preservation, safe handling, and reduced postharvest losses in the pumpkin value chain.

Keywords: ANK Ruhunu; dehydration; packaging materials; pumpkin; rehydration

Physicochemical Properties, Fatty Acid Profile, and Storage Stability of Oil from Kokatiya (*Garcinia terpnophylla*) Seeds

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Abstract

The study evaluated the physicochemical characteristics, fatty acid composition, and oxidative stability of oil extracted from kokatiya (*Garcinia terpnophylla*) seeds to assess its potential as a novel edible oil in Sri Lanka. The experiment followed a Completely Randomized Design with three replicates. Kokatiya seeds collected from different regions were subjected to Soxhlet extraction, and the oil properties were compared with coconut, sesame, and palm oils. The oil yield of kokatiya was 42.88±0.58%, with a chroma value of 17.47, indicating a bright yellow hue. The acid value and free fatty acid content of kokatiya oil (2.90±0.61 mg KOH/g and 1.04±0.22%, respectively), coconut oil (3.31±0.19 mg KOH/g and 1.18±0.07%, respectively), and palm oil (2.08±0.14 mg KOH/g and 1.67±0.09%, respectively) were significantly lower (p<0.05) than those of sesame oil (13.95±0.63 mg KOH/g and 7.02±0.32%, respectively), suggesting better quality and stability. The specific gravity (0.862±0.01) and melting point (38.2±0.76 °C) of kokatiya oil were comparable to palm oil, indicating its suitability for culinary uses and processed foods. Gas chromatographic analysis revealed high proportions of stearic (44.08%) and oleic acids (54.81%), making it a promising source of healthy monounsaturated and saturated fatty acids. Coconut oil consists of 27.83% myristic acid and 9.85% palmitic acid, while sesame oil consists of 56.18% linoleic acid, 33.99% oleic acid. Palm oil contained 56.26% oleic acid and 26.43% palmitic acid. The induction times of 9.12, 4.17, and 1.70 hours at 120, 140, and 150 °C, respectively, demonstrated moderate oxidative stability at lower temperatures but thermal sensitivity at higher temperatures. Overall, kokatiya seed oil exhibits desirable physicochemical attributes and fatty acid composition, suggesting its potential as a viable edible oil source for Sri Lanka.

Keywords: *Garcinia terpnophylla*; kokatiya seed oil; fatty acid profile; oxidative stability, edible oil

Functional Property Analysis of Probiotic-derived Exopolysaccharides

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Abstract

Exopolysaccharides synthesized by probiotic lactic acid bacteria are known for their functional applications and potential health benefits in the food sector. This study aimed to isolate, quantify, and analyze the functional properties of exopolysaccharides produced by selected indigenous probiotic lactic acid bacteria strains isolated from buffalo curds. and identify strains with better functional properties. The strains were cultured in MRS broth and M17 broth under optimized incubation conditions. Exopolysaccharides were extracted by centrifugation, addition of trichloroacetic acid, and ethanol precipitation, followed by purification through dialysis and lyophilization. Exopolysaccharides were evaluated based on production yield, antioxidant activity, emulsification, anti-inflammatory ability, and Fourier transform infrared spectroscopy analysis. Results indicated that *Lactobacillus delbrueckii* subsp. *bulgaricus* strain KAN-LB_525 exhibited the highest exopolysaccharide production (1.32±0.04 g) among the tested strains. *Lactobacillus helveticas* strain LH_91 exhibited the highest anti-inflammatory activity (53.46±0.05%), and *Streptococcus thermophilus* strain BLG_421 exhibited the highest emulsifying activity index (17.30±0.03%) among the tested exopolysaccharides. *Streptococcus thermophilus* strain BLG_421, *Lactobacillus delbrueckii* subsp. *bulgaricus* strain KAN-LB_525, *Lactobacillus delbrueckii* subsp. *indicus* strain THS-IN_36, and *Lactobacillus delbrueckii* subsp. *indicus* strain SUR-IN_55 possessed greater antioxidant activity across all three DPPH, ABTS, and FRAP antioxidant testing. *Lactobacillus delbrueckii* subsp. *indicus* strain THS-IN_36 exhibited the most prominent and well-defined FTIR spectral features, indicating the strongest presence of characteristic functional groups associated with exopolysaccharides. In conclusion, probiotic lactic acid bacteria-derived exopolysaccharides possess distinct functional properties that may contribute to their techno-functional roles in the food industry.

Keywords: exopolysaccharides; probiotics; lactic acid bacteria; biopolymers; functional properties

Optimization of Partial Gelatin Replacement in Set Yoghurt using Exopolysaccharides Producing Probiotic Lactic Acid Bacteria

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Abstract

Exopolysaccharides produced by lactic acid bacteria are natural biopolymers that can enhance yoghurt texture, water holding capacity, and stability, offering a clean label alternative to stabilizers such as gelatine. Exopolysaccharides-producing indigenous lactic acid bacteria strains of *Lactobacillus delbrueckii* subsp. *indicus*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, and *Streptococcus thermophilus* isolated from traditional Sri Lankan buffalo curd were tested for their potential as partial gelatine substitutes in set yoghurt. Multiple co-culture ratio combinations of these strains with gelatine concentrations ranging from 0 to 0.6% (w/v) were used to produce set yoghurt. Physicochemical (pH, syneresis, water-holding capacity, viscosity) and textural (hardness, adhesiveness, gumminess, stringiness, chewiness, resilience) properties were measured over 28 days of refrigerated storage. Response surface methodology (RSM) with an I-optimal design was used to identify the optimal formulation. RSM optimization revealed that a co-culture of *L. delbrueckii* subsp. *indicus* SUR-IN_55, *L. delbrueckii* subsp. *bulgaricus* KAN-LB_525, and *S. thermophilus* BLG-ST_421 in a 1:1:2 ratio with 0.45% gelatine achieved the highest desirability score (0.717). Compared to the commercial set yoghurt control, this formulation significantly reduced ($p<0.05$) syneresis by 2.69%, increased water holding capacity to 75.30%, and maintained an optimal pH of 4.5. Hardness (252.08 g), adhesiveness (1.10 mJ), and cohesiveness (1.81) values obtained for the formulation were comparable to, or greater than, the corresponding values observed in the commercial yoghurt. The combination of EPS and reduced gelatine produced a more stable gel network, improving structural integrity, moisture retention. Model validation confirmed that there were no significant differences ($p>0.05$) between the predicted and observed values for all parameters, demonstrating the reliability of the optimization. These results indicate that partial replacement of gelatine with exopolysaccharides producing lactic acid bacteria is a practical and effective approach for enhancing yoghurt quality while reducing dependence on animal-derived stabilizers.

Keywords: yoghurt; exopolysaccharides; response surface methodology; physicochemical properties; texture profile analysis

The Occurrence of Microplastics on Vegetable Surfaces in Nuwara Eliya

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Abstract

Vegetables have been identified as a major pathway for microplastic accumulation in humans. Microplastics can accumulate on vegetables either through soil or air exposure. This study aimed to quantify microplastics on the leaf surfaces of salad, carrot, broccoli, onion, and cabbage cultivated in Nuwara Eliya, Sri Lanka. The washing water from the collected samples was digested using the Fenton reaction until no visible residues remained. The resulting solution was filtered through glass microfiber filters. A stereomicroscope was used to identify the size, color, and morphology of the microplastics. The average microplastic content on the leaves was 0.84 particles per gram (AMP/g). The largest observed particle measured 1518.8 µm, and the smallest, 2.7 µm, was found on the broccoli leaves. Microplastic abundance showed a significant difference among the tested groups. The Tukey test indicated that microplastic particles in broccoli were significantly different from those in the other vegetables, possibly due to its distinct physical characteristics. Among the identified microplastics, 48% were blue, 25% black, 9% green, and the remaining microplastics were red, white, or brown. Regarding morphology, 73% of microplastics were fibers, while 27% were fragments. These findings indicate notable airborne pollution in the agroecosystem and suggest that plant surfaces can act as sinks for microplastics. The results also imply that microplastic deposition on the leaf surface depends on their physical characteristics. Therefore, proper washing of vegetables before consumption is essential, and modifying food consumption habits could help reduce microplastic intake through leafy vegetables.

Keywords: air-borne microplastics; leafy vegetables; Nuwara Eliya

Geo Resources, Geo Environment, and Geotechnics

Determination of a Suitable Load-bearing Capacity Equation for Rock-socketed Piles in Sri Lanka using Empirical and Probabilistic Approaches

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Abstract

In Sri Lanka, the rapid demand for deep, stable foundations like rock-socketed piles is driven by limited suitable land and the need to support heavy structural loads. This study addresses the existing challenges by proposing a probabilistic framework for estimating pile load capacity. The method integrates laboratory-based unconfined compressive strength (UCS) values with established empirical equations for end bearing and shaft resistance. To quantify natural geological variability, site-specific core sample UCS values are supplemented using stochastic simulation, specifically the normal distribution. A computer program was specially developed to automate UCS calculation, perform capacity estimations, and effectively evaluate failure probabilities through the comparison of calculated pile capacity and applied loads. The program is also used to compare and assess the design reliability of different empirical models. Calibrated to local data, the probabilistic approach presents a valuable, reliable, and cost-effective alternative to traditional deterministic methods in regions with scarce borehole information. In this research, a stable solution was achieved by artificially generating approximately 100,000 parameter values through stochastic simulation. Our approach helps geotechnical design decision-making and enables the application of reliability-based standards in Sri Lankan design practice.

Keywords: rock-socketed pile; unconfined compressive strength; load-bearing capacity; probabilistic design

Enhancing Usability of Clayey Soil for Embankments on the Central Expressway, Sri Lanka, through Plasticity Index-controlled Soil Blending

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Abstract

Expansive clayey soils, excavated along Sri Lanka's Central Expressway, pose significant geotechnical challenges because of high plasticity, low bearing capacity, and excessive volume changes when used for embankments. The development of cost-effective and regionally adaptable soil blends by targeting plasticity index (PI) and liquid limit (LL) through controlled mixing is the primary focus of this study. Eight clayey soil samples were collected from multiple soil stockpile locations along the ongoing construction sections and the proposed path of the Central Expressway Section III. The first phase focused on determining the LL and PI values of each individual soil sample to assess plasticity properties. Based on preliminary results, selected soils were blended with each other in varying ratios (e.g., 25:75, 50:50, 75:25, and 85:15) to evaluate whether intermixing of disposed soils can achieve project acceptable LL and PI. Later, the performance of blends was further tested with modified proctor compaction tests and showed reasonable optimum moisture contents. However, the maximum dry densities needed further improvements. Preliminary results indicated that targeted PI reduction (≤12) is achievable with sand-based soil blends, leading to better workability, strength, and long-term performance. This blended approach offers a sustainable, low-cost solution for improving problematic clayey soils in infrastructure development. The outcome will support context-specific geotechnical design for expressway construction in tropical environments like Sri Lanka.

Keywords: soil blending; subgrade improvement; central expressway project; expressway embankments; plasticity index

Geospatial Assessment of Surface Water Availability for Sustainable Water Management in Sri Lanka

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Abstract

In developing countries, due to rapid land use changes, understanding the spatial variation of surface water availability is important for water management practices. By integrating multi-criteria decision analysis with remote sensing indices, this study proposes a comprehensive approach for assessing surface water availability in Sri Lanka. Key factors such as rainfall, drainage density, surface water area, and evapotranspiration were selected, normalized, and weighted using the analytical hierarchy process to produce a Surface water availability index (SWI) with an acceptable consistency ratio (CR=1.7%). SWI was developed at 50 m resolution and revealed that 39% of the country falls under low or very low availability zones, while 21% is classified as high. The main objective is to map and evaluate surface water availability across divisional secretariat divisions (DSDs) and provinces using spatial indicators and decision-support methods. The spatial analysis showed Mannar town had the lowest SWI (0.0897) and Elapatha the highest (0.7566). When considering 340 DSDs, 188 had SWI above the national mean (0.3144), indicating better availability. Provinces such as Northern, North Central, Eastern, and Uva fell below the national average, indicating drought vulnerability, while Western and Sabaragamuwa showed higher availability. SWI was highest in water bodies (0.39) and vegetation (0.32), but lower in built-up (0.28) and barren lands (0.26). Correlation analysis revealed a moderate negative correlation between SWI and land surface temperature (r=-0.44), a weak positive correlation with the normalized difference vegetation index (r=0.25), and a weak negative correlation with the normalized difference water index (r=-0.21). This integrative approach offers a scalable, practical decision-support tool for drought mitigation, equitable resource planning, and long-term water governance. The accuracy of this method can be further improved through the use of higher-resolution, accurate data and relevant environmental and hydrological variables to directly inform sustainable water and land-use policy.

Keywords: analytical hierarchy process; drought mitigation; water policy; multi-criteria decision analysis; spatial prioritization

A Slope Erosion Controlling Method with Waste Tyres and Plants: Design and Simulation

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Abstract

The growing issue of waste tyre disposal is posing significant environmental challenges. Re-purposing waste tyres in geotechnical engineering applications, such as slope stabilization, offers a cost-effective solution, as traditional slope stabilization techniques are costly and not environmentally friendly. This study focused on minimizing the environmental damage caused by waste tyre accumulation with a practical and cost-effective solution. Moreover, this study considered fast-growing and suitable plant species such as Vetiver grass, or Chinese silver grass, Cogon grass, and Lemongrass to control soil erosion, as controlling soil erosion further enhances soil stability. Laboratory tests were conducted on soil samples collected from the landslide prone location at Nuwara Eliya district, Sri Lanka, to determine key geotechnical properties. Numerical simulations were then performed to assess the performance of tire-based retaining structures reinforced with steel bars. The analysis revealed that the use of waste tyres arranged in a stepwise configuration significantly increased the Factor of Safety (FoS) from 0.5 to 0.912, particularly in weak soils such as clayey silt, which was sampled. Additional simulations using parameters from another soil type confirmed the effectiveness of the proposed design with an increased safety factor from 1.32 to 1.81. The Vetiver grass, Lemongrass, Chinese Silver Grass, and Cogon Grass are some of the fast-growing plant species that have been identified to reduce surface runoff, enhance soil strength, and slope stability by reinforcing roots and protecting slopes. Root architecture, plant adaptability, growth rate, and how they affect soil erosion in various climatic and soil conditions were considered to evaluate the effectiveness of plants for slope stability. As per this study, the tyre-based stabilization, combined with vegetation, is a technically sound and environmentally friendly alternative to traditional slope reinforcement methods.

Keywords: slope stabilization; soil erosion; waste tyres; vegetative erosion control

Multi-parameter Ocean-atmosphere Interactions in the Indian Ocean Around the Western Sri Lankan Region from 2002-2025

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Abstract

This study presents a comprehensive analysis of multi-parameter ocean-atmosphere interactions in the Western Indian Ocean around Sri Lanka (78.75°E-80°E, 5.5°N-10°N) using 23 years of satellite-derived and reanalysis data (2002-2025). The relationships between sea surface temperature (SST), chlorophyll a concentration, precipitation, heat fluxes, and atmospheric dynamics to understand climate variability and marine ecosystem responses in this coastal region were examined. The analysis revealed significant inverse correlations between SST and biological productivity, with chlorophyll a concentrations showing strong negative relationships to temperature variations (r=-0.742, p<0.001). This correlation strength is notably higher than reported values from the Bay of Bengal (r=-0.35 to -0.55), suggesting that thermal stratification exerts stronger control on productivity in Sri Lankan coastal waters compared to the salinity-dominated Bay of Bengal system. Long-term trends indicate consistent warming of 0.15 °C per decade, exceeding global ocean averages and comparable to the upper range of Arabian Sea warming rates (0.12-0.15 °C per decade), coupled with a modest increase in primary productivity (+0.04 mg m^{-3} per decade). This contrasts with declining productivity trends reported for the central Arabian Sea (-0.03 to -0.08 mgm^{-3} per decade) and stable trends in the Bay of Bengal, suggesting region-specific responses to climate forcing. Strong positive correlations were observed between latent heat flux and precipitation patterns (r=0.683), suggesting robust monsoon-driven ocean-atmosphere coupling. Seasonal analysis demonstrated peak chlorophyll a concentrations during the southwest monsoon (June-September, mean: 1.89 mgm^{-3}) when cooler temperatures and enhanced nutrient availability promote phytoplankton growth, though the seasonal amplitude (factor of ~2) is substantially lower than the Arabian sea upwelling zones (factor of 3-10). While our statistical models showed reasonable calibration performance (R^2=0.78), independent validation revealed reduced predictive skill (R^2=0.54), highlighting fundamental limitations of correlation-based approaches. These findings contribute to understanding regional ocean-atmosphere dynamics.

Keywords: ocean-atmosphere interactions; sea surface temperature; chlorophyll; monsoon; climate variability

Risk Assessment and Optimization of Emergency Routing in Flood-prone Areas using Geospatial Techniques: A Case Study of the Gampaha DSD

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Abstract

Floods are one of the most devastating natural disasters in the world. Sri Lanka is also a country that is severely affected by floods during the monsoon season. The Gampaha divisional secretariat division (DSD), located in the Attanagalu oya basin, is also prone to flooding. 8-12% of the total population and 23-30% of the total land area are affected by floods in the Gampaha DSD. The lack of a spatial risk assessment and optimal evacuation routes for emergency management increases the impact of a disaster. This study aims to assess the flood risk and optimal emergency routes using advanced geospatial techniques. Flood risk is evaluated through a weighted overlay of hazard and vulnerability factors, including rainfall, elevation, slope, drainage density, population density, building density, land use, and proximity to roads from 2023-2024, and the Analytical Hierarchy Process is used to assign weights to these factors. Geospatial datasets were obtained from satellite imagery, the Survey Department, and OpenStreeMap. ArcGIS Network Analysis is used to identify vulnerable routes for flood and develop optimal evacuation routes from identified assembly points to emergency centers under minor (4.40 m) and major (5.50 m) flood scenarios. The results identified a very high flood risk area of 4.69 km^2 and a high flood risk area of 13.49 km^2. It was found that most of the flood-prone areas are low-lying areas, and roads in low-lying areas are also at high risk of flooding. Since transportation routes are also vulnerable to flooding, this also significantly affects the efficiency of evacuating affected people in those areas. For this reason, the optimal evacuation routes required during flood conditions were assessed, and the routes were in the range of 2-3 km. These routes ensure fast and safe access from assembly points to emergency centers during flood conditions. This research demonstrates the critical role of GIS in developing effective flood risk assessments, evacuation plans, as well as disaster preparedness and resilient urban planning.

Keywords: disaster management; emergency routing; flood risk assessment; GIS; network analysis

Effect of Particle Size and the Pore Liquid Chemistry on the Plasticity and Shrinkage Characteristics of Bentonite-Amended Clay Liners in Waste Containment Facilities

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Abstract

This study investigated the effects of particle size distribution and pore liquid chemistry on the plasticity characteristics of bentonite-amended clay liners. Bentonite-amended clay samples were prepared by varying the bentonite content as 5, 10, 15, and 20% to investigate the effect of bentonite content on the plasticity and shrinkage characteristics of the liner. To investigate the effect of particle size, each sample containing 5 and 10% bentonite were mixed with 20% medium sand (0.25-0.50 mm) and 20% coarse sand (1.00-2.00 mm) separately. Shrinkage characteristics of each sample were investigated under water, 1M $CaCl_2$, and 1M NaCl as pore liquid. Results showed that increasing bentonite content elevated the liquid limit, plastic limit, and plasticity index with water yielding the highest values, followed by NaCl and $CaCl_2$. The results demonstrate that pore fluid composition significantly influences volumetric shrinkage and desiccation cracking. Based on the comprehensive analysis of shrinkage behavior in moisture retention studies, coarser particles lose moisture more rapidly compared to finer particles due to larger pore spaces that facilitate faster water drainage and $CaCl_2$ plays a crucial role in stabilizing the soil structure, reducing shrinkage-induced cracks, and enhancing overall liner performance. For optimal low-permeability barrier liners, a combination of fine particles with 10% bentonite is recommended, as this balances moisture retention while minimizing desiccation cracks, ensuring long-term liner integrity. The findings provide insights for optimizing bentonite-amended clay liners design to enhance durability and minimize shrinkage-related failures in waste containment applications.

Keywords: bentonite-amended clay liners; shrinkage behavior; particle size distribution; pore liquid chemistry; plasticity characteristics

Evaluating the Effectiveness of Flood Risk Mitigation Measures in Galle City Region

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Abstract

Flooding is one of the most pervasive hydrological hazards worldwide, with its frequency and severity exacerbated by ongoing urbanization and climate change. Galle city experiences recurrent severe flooding caused by inadequate drainage capacity, blocked waterways, and unplanned urban development, resulting in significant socioeconomic impacts. This study evaluates the effectiveness of flood damage mitigation measures implemented under the strategic cities development project to address the persistent flooding issues in Galle city. The research focuses on the structural mitigation measures, assessing the influence of implemented flood mitigation initiatives on flood extent, intensity, and community resilience. A mixed-methods approach, including literature review, qualitative assessments, and satellite imagery analysis, the study identifies vulnerable areas and evaluates the efficacy. Key indicators such as flood extent, intensity, frequency, and community perceptions were analyzed using Landsat 8 imagery, Normalized difference vegetation index (NDVI), and SPSS statistical tools. Flood-affected areas were mapped using unsupervised classification methods, while the NDVI was applied to distinguish land cover types and identify areas with reduced natural water absorption capacity, contributing to flood vulnerability assessment. Community perceptions and satisfaction levels were analyzed using SPSS statistical tools. Results indicate a significant 86% reduction in flood-affected areas, from approximately 9.47 km² in 2014 to 1.35 km² in 2021, demonstrating the effectiveness of canal rehabilitation, improved drainage, and bank protection works under the project. Although community feedback acknowledged these improvements, concerns regarding maintenance, waste accumulation, and limited engagement. Persistent challenges such as maintenance gaps, waste accumulation, and limited public satisfaction highlight the need for integrated flood risk management strategies that integrate both structural improvements and community-based initiatives to strengthen resilience against future flooding events. Emphasis is placed on the importance of continuous evaluation, the adoption of technological innovations such as real-time monitoring systems, and the community-driven feedback mechanisms to enhance preparedness and response.

Keywords: flood disaster; urban resilience; flood hazard mitigation; remote sensing

Industrial Electronics

Development of Degradable, Flexible, and Conductive Plastic Filament Incorporating Graphite and Graphene for use in 3D Printing of Wearable Electronic Sensors using PLA

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Abstract

Wearable electronic sensors are often made from rigid, non-biodegradable materials, limiting their comfort, environmental sustainability, and long-term usability in health monitoring applications. This study introduces a novel, flexible, conductive, and 3D-printable bio-composite material for biometric sensors. The material system integrates polylactic acid (PLA) for biodegradability, chloroprene rubber for flexibility, and carbon-based fillers, including graphite and graphene nanomaterials for electrical conductivity. Composites were fabricated using solvent casting and hot press molding, incorporating varying amounts of chloroprene rubber (2-20 wt%), graphite (10-40 wt%), and graphene (1-4 wt%). The materials were characterized for their mechanical, thermal, and electrical properties. The composite containing 10 wt% chloroprene rubber exhibited optimal flexibility and tensile strength (32±4 MPa), while that with 1 wt% graphene nanomaterial showed the highest electrical conductivity (9.52×10^{-5} S/m) and thermal stability up to 500 °C. FTIR analysis confirmed enhanced graphene- PLA interactions, and TGA indicated improved thermal resistance. Mechanical testing revealed enhanced flexibility (7.5 mm deflection) and relatively high hardness (95±5 Shore D) with graphene incorporation, although tensile strength decreased at higher graphite content. Notably, the composite with 4 wt% graphene showed good 3D printability using FDM technology. This study successfully presents a biodegradable, flexible, and conductive filament developed from high-purity Sri Lankan vein graphite and PLA. The resulting bio-composite offers a promising, eco-friendly alternative to conventional rigid sensor substrates, with strong potential for use in real-time, comfortable wearable electronics.

Keywords: flexible bio-composites; wearable sensors; graphene; polylactic acid; 3D-printing

An Automated IoT-integrated Urine Output and pH Monitoring System for Early Detection of Renal Complications in Dengue Patients

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Abstract

Dengue fever, a mosquito-borne viral disease, remains a significant health concern in Sri Lanka, where continuous monitoring of renal function and hydration status is crucial for effective patient management. Urine output and pH are crucial indicators for evaluating renal function and metabolic balance. Conventional manual measurement methods are time-consuming, labor-intensive, and prone to human error, often delaying vital clinical interventions. This study presents a novel, low-cost automated urine monitoring system capable of continuously measuring urine volume and pH in real time using an ESP32-based IoT platform. The system integrates an ultrasonic sensor for volume estimation and a PH-4502C pH sensor, both calibrated in accordance with standard laboratory procedures to ensure accuracy and repeatability. The calibration results showed 98.62% accuracy for urine volume measurement and stable voltage outputs for pH, with 2.51 V at pH 7, confirming sensor precision. Sensor data are processed by the ESP32 microcontroller, displayed locally on a 20×4 LCD, and transmitted wirelessly to a mobile application for real-time graphical visualization and health-risk indication. Integration with an IoT-based mobile platform enables continuous remote monitoring, allowing healthcare providers to track patients without constant bedside presence. Validation tests confirmed stable sensor performance, accurate data transmission, and consistent monitoring. The proposed system delivers a practical and standardized approach for early detection of renal and metabolic complications in dengue patients, showing strong potential to enhance patient care and clinical responsiveness in resource-limited healthcare environments.

Keywords: dengue; urine monitoring; pH measurement; urine volume; IoT; real-time health monitoring

Development of Field Instrument for Measuring Rope Slippage in Traction Elevator

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Abstract

A study investigating passenger comfort in traction elevators identified traction rope slippage as a contributing factor. To measure this slippage, a contact-based approach using encoders was found to be a practical and reliable method for rotary motion measurement. This technique measures the relative motion between the traction sheave and the hoisting ropes to calculate slippage at various elevator travel speeds. Modern elevators achieve precise control through the use of motion measurement sensors. Quantitative detection of rope travel is more difficult than that of the traction sheave. Thus, the research intended to find an alternative to measure the motion of the passenger cabin. The study evolved to a field-level experiment after the initial apparatus tests, simulating different weight conditions in an actual passenger elevator. The experiments revealed that increasing the weight ratio between the passenger car and the counterweight leads to a noticeable increase in rope slippage, highlighting the sensitivity of slippage to tension ratios in traction systems. The field-level experiments were conducted to examine the traction slippage behavior of an elevator traction machine under no passenger load conditions. Results indicated that, in the absence of passenger weight, the traction machine exhibits greater slippage during upward movement compared to downward travel. The experimental setup yielded promising results from both experimental tests and field measurements. Ultimately, the encoder-based motion measuring systems demonstrated potential for field applications when integrated with enhanced mechanisms.

Keywords: rope slippage; encoders; traction sheave; elevator

Interactive Media Technologies

Revitalizing Sri Lankan Education: Bridging the Gap in Digital Art and Animation for Primary and Secondary Students

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Abstract

Sri Lanka's government education system continues to focus on traditional visual arts, leaving students unprepared for the global digital creative economy. This research aims to bridge that gap by experimentally integrating digital art and animation education into government schools to evaluate its technical, innovative, and educational impact. The primary objective is to assess the feasibility of implementing a scalable model that enhances students' digital literacy, creative expression, and entrepreneurial abilities through structured technological educational programs. Ten government schools representing diverse socio-economic regions participated in the five-month pilot project. Each school received digital art equipment like graphic tablets, laptops, and open-source software (Krita), followed by a one-month structured training program delivered by professional digital artists. The program focused on fundamental digital illustration, color theory, and animation principles. The authors measured the outcomes through mixed-method data collection, pre- and post-skill assessments, project evaluations, and interviews with students and teachers. The results showed that students' technical skills and creative output improved significantly, and we can see improvements in their learning of digital art. Students became more motivated and interested in staying involved in long-term learning, and they also began exploring future career opportunities. Teachers reported that students were more engaged in the class and agreed that they wanted training in digital learning methods. Systemic problems, such as outdated curricula and insufficient ICT infrastructure, were identified as significant challenges. The study finds that early integration of digital creative education is both viable and transformative for Sri Lanka's education system. It strengthens 21st Century competencies, promotes innovation, and contributes to national economic growth by developing the creative industry. These findings provide a policy-relevant framework to modernize arts education and align it with global standards.

Keywords: digital art and animation; creative education; digital literacy; curriculum innovation; Sri Lanka

Materials Engineering and Process Technology

Development of a Natural Fiber Reinforced Plastic Composite Utilizing *Luffa cylindrica* Fiber and Acrylonitrile Butadiene Styrene (ABS)

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Abstract

Investigating the potential use of *Luffa cylindrica* fibers (LCF) as an eco-friendly reinforcement for Acrylonitrile Butadiene Styrene (ABS) composites aims to improve their mechanical properties and environmental performance, thereby introducing better application properties. This study examines various composite formulations, and three surface treatments (alkali, bleaching, and silane) were applied to enhance the fiber-matrix interface, which is essential for improving mechanical strength. Composites were fabricated with different fiber loadings (1, 5, and 10% by weight) using three treatment methods to identify the optimal mechanical properties. The findings reveal that alkali-bleached silane-treated composites generally exhibited superior tensile strength, impact resistance, and thermal stability compared to other types. The findings reveal that the surface treatments significantly improve the mechanical properties of the composites, with the alkali + bleached + silane treated composites showing the highest tensile strength (34.6 MPa) and compression strength (159.2 MPa). Moreover, the study demonstrates that LCF/ABS composites exhibit superior impact resistance and thermal stability compared to non-treated composites and synthetic alternatives. A key discovery in this study was the improvement in the thermal properties of the composites, with the inclusion of treated LCF significantly increasing the thermal resistance, making these composites ideal for applications that require high thermal resistance. Additionally, the biodegradability of LCF/ABS highlights its potential for reducing environmental impact, making this research particularly relevant for industries focused on achieving sustainability goals. This research underscores that LCF/ABS composites present a sustainable alternative to synthetic fiber composites, suitable for use in automotive, construction, and packaging industries. The study acknowledges the benefits of natural fiber composites and enhances understanding of the performance implications of fiber treatments and loadings, setting a foundation for future innovations in composite technology.

Keywords: ABS composites; *Luffa cylindrica*; mechanical properties; surface treatment

Chemiresistive Sensing of Free Chlorine in Water using an α-Titanium Phosphate-Based Sensor

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Abstract

The free chlorine content in water must be carefully monitored and controlled within established limits to ensure water quality, human health, and environmental safety. In this study, we report the successful development of a novel and simple sensor based on α-titanium phosphate for detecting free chlorine in water at room temperature. The α-titanium phosphate was synthesized using a KOH roasting and H_3PO_4 leaching process using ilmenite ($FeTiO_3$), providing value addition to ilmenite beach sand in Pulmoddai, Sri Lanka. Natural graphite and carboxymethyl cellulose were included as minor components to enhance sensor performance. The unique crystal structure of α-titanium phosphate offers interlayer spaces with high adsorption capacity, while natural graphite contributes electrical conductivity, and carboxymethyl cellulose imparts film-forming properties for the sensor. The sensor was fabricated using the doctor blade method. Characterization by X-ray diffraction, Fourier-transform infrared spectroscopy, and Raman spectroscopy confirmed the successful synthesis of α-titanium phosphate and the sensor composition. Electrical measurements using a four-probe conductivity meter showed ohmic behavior with a conductivity of 0.31 S/m. To evaluate the sensor performance as a voltage response, the LabJack U3-HV apparatus, combined with a voltage-dividing circuit, was equipped. The sensor demonstrated excellent sensitivity to free chlorine, measuring 11.34 mV/ppm, with a detection limit as low as 0.5 ppm and a calibration range from 0.5 to 100 ppm. The average response time was approximately 2 minutes, with recovery times between 20 and 30 seconds. The sensor exhibited good reproducibility, maintaining a consistent response within ±2.29% deviation across four consecutive measurements. Additionally, the sensor exhibited stable aging performance over a weak against swelling-induced breakage.

Keywords: α-titanium phosphate; free chlorine sensor; ilmenite; room temperature

Synergistic Charge Transfer in Electrospun Go-Ni-ZnO Membranes: A Visible-Light-Driven Platform for Optimized Photodegradation

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Abstract

Photocatalysis drives photodegradation processes, enabling the efficient breakdown of contaminants and unlocking new possibilities for environmental remediation and biomedical innovation, especially when employing transition metal-oxide nanoparticle systems such as ZnO. With limitations like the higher band gap and the lower surface area, the photodegradation efficiency is not satisfactory. In addition to increasing the photocatalytic efficiency of ZnO by doping Ni to lower the band gap, graphene oxide (GO) can be incorporated to enhance photocatalytic activities and increase its durability and resistance to photo-corrosion, which could be due to the electron-hole recombination by increasing the surface area and conjugated electron cloud. Electrospinning backs up the fabrication of GO-Ni-ZnO mats, which are incorporated with the cellulose acetate (CA) polymer. The outcomes exhibit a notable improvement in the organic dye methylene blue's photocatalytic breakdown when exposed to visible light within a short time range, underscoring the membranes' potential for industrial wastewater treatment. After 15 minutes, a nanohybrid consisting of the GO and Ni-ZnO incorporated into a cellulose acetate electrospun mat showed the greatest photodegradation activity of 93.41%. This outcome validates the benefits of the nanohybrid system's synergistic activity. The DPPH assay was used to measure radical scavenging activity (RSA), which underlays the main mechanism for this occurrence. With a higher rate constant of 0.321 mM/min for the nanoparticles, the nanohybrid mat showed the highest RSA, achieving 80.4% of radical scavenging activity after an hour. This nanohybrid (GO-Ni-ZnO), has indicated a bandgap energy of 3.08 eV, providing more evidence of the nanohybrid system's efficacy in visible light. Collectively, the development of electrospun GO-Ni-ZnO nanomembranes presents a promising approach to boosting photocatalytic effectiveness and antimicrobial activity while delivering sustainable solutions across diverse fields.

Keywords: antibacterial action; electrospinning; photocatalyst; synergistic activity; water purification

Development of Zinc Oxide/Reduced Graphene Oxide Composite for Nonenzymatic Electrochemical Glucose Biosensor

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Abstract

Diabetes mellitus is a serious metabolic disease due to its long-term complications, such as damage to nerves, kidneys, blood vessels, eyes, and skin. Modern medicine has not yet found an exact treatment for diabetes. Therefore, it is essential to perform self-testing to monitor blood glucose levels and manage the disease. Different types of glucose biosensors exist worldwide. However, Sri Lanka struggles to purchase them to manage its diabetic population. As a result, the high cost of these technologies and the challenge of managing diabetes within the country are critical challenges. Consequently, there is a high demand to develop a new glucose biosensor using simple methods and local Sri Lankan resources. This study explored the development of a novel graphene-based composite for nonenzymatic electrochemical glucose sensing, utilizing a simple approach and Sri Lankan graphite. The composite was created by combining zinc oxide and reduced graphene oxide and was synthesized through chemical and hydrothermal reduction methods. Material characterization was conducted using Scanning electron microscopy, Particle size analyzer, X-ray photoelectron spectroscopy, and Fourier transform infrared spectroscopy. For glucose detection, a glassy carbon electrode modified with the composite was used to perform electrochemical analysis with a Metrohm Autolab Potentiostat. All characterization techniques confirmed the successful synthesis of the composite. The cyclic voltammetry results demonstrated excellent electrocatalytic activity toward glucose detection in the presence of NaOH, showing an oxidation peak with an anodic peak current of 2.23×10^{-4} A at the highest glucose concentration (15 mM). This study indicates significant potential for applying zinc oxide/reduced graphene oxide composite-based glucose biosensors in Sri Lanka's medical field.

Keywords: diabetes mellitus; electrochemical biosensor; nonenzymatic sensing; zinc oxide; reduced graphene oxide; composite

Development of Novel Anti-ageing Coating for Saline Rubber Applications Utilizing Graphene-Calcium Carbonate Encapsules into Chloroprene Latex-based Coating

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Abstract

Ozone-induced degradation is a critical concern for rubber products exposed to outdoor environments, leading to surface cracking, loss of elasticity, and shortened service life, particularly in applications such as bicycle tire sidewalls. To address this, a novel graphene-calcium carbonate microcontainer-based anti-ageing coating was developed using chloroprene latex matrix. The microcontainers were synthesized via ultrasonication-assisted encapsulation of reduced graphene oxide (rGO) within calcium carbonate ($CaCO_3$) shells, followed by shear mixing and drying. These microcontainers were then incorporated into chloroprene latex coatings alongside styrene-acrylic binder, zinc oxide, ZMBT, and sulfur, using ball milling and emulsification techniques to ensure uniform dispersion. Key performance parameters were assessed, including ozone resistance (ASTM D1149), adhesion strength (ASTM D3359), drying time (ASTM D1640), density (ASTM D1475), and dry film thickness. Structural and chemical characterizations were carried out using FTIR to confirm graphene–polymer interactions and the successful encapsulation of rGO within $CaCO_3$. Results revealed that the coating containing 5 phr of rGO–$CaCO_3$ microcontainers demonstrated the most balanced performance, showing no visible discoloration after 72 hours of water immersion, while higher loadings caused mild yellowing due to filler agglomeration. FTIR spectra verified strong interfacial bonding through Si-O-Si and C=C linkages, indicating improved network integrity. The optimized formulation exhibited excellent adhesion (rating 5/5) and short, uniform drying times (~5 minutes) on both metal and rubber substrates. These enhancements are attributed to the synergistic effect of the encapsulated graphene, which provided antioxidative functionality and improved interfacial compatibility within the latex matrix. This work introduces a practical and scalable strategy to improve the durability of rubber components, particularly in transportation and outdoor applications, where ozone exposure is a persistent challenge.

Keywords: chloroprene coating; rubber protection; non-staining antiozonant; ozone degradation;

Sansevieria cylindrica Fiber Reinforced Low-density Polyethylene Composite for use as Non-structural Partition Boards

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Abstract

This study explores the development of sustainable LDPE composites reinforced with Sansevieria cylindrica (SC) fibers, focusing on improved mechanical performance and environmental sustainability for partition board-like non-structural applications. SC fibers were selected due to their sustainability, biodegradability, and abundance in Sri Lanka. LDPE, selected by considering the low density (0.92 g/cm³) and convenient processing, served as the polymer matrix. The SC fibers were extracted using water retting and subjected to three surface treatments, followed by alkaline treatment (5% NaOH, 90 min), bleaching (6% $NaClO_2$ with acetic acid), and silane treatment (5 wt% SI-69 in ethanol/water). These treatments are triggered to improve fiber-matrix adhesion by removing non-cellulosic components and enhancing surface reactivity. Composites were prepared using 1, 5, and 10% fiber loadings for untreated, alkali-silane-treated (ATST), and alkali-bleach-silane-treated (ATBTST) fibers were manufactured using compression molding. Thermogravimetric analysis demonstrated thermal stability up to ~400°C, with ATBTST showing improved resistance to thermal degradation. Fourier transform infrared spectrometry confirmed successful removal of lignin and hemicellulose and formation of Si-O-C and Si-O-Si bonds in treated samples, indicating enhanced interfacial bonding. Mechanical tests showed tensile strength (ASTM 638) peaking at 8.5 MPa at 1% loading for ATBTST, due to better fiber dispersion and adhesion. Compression strength reached 48.2 MPa at 5% loading in ATST composites, while impact strength (ASTM D 256) was highest at 59,434 kJ/m^2 in 10% ATBTST samples, indicating improved energy absorption. Hardness (ASTM D 2240) generally decreased with increased fiber loading, though ATBTST maintained higher values than ATST. Density rose with fiber content, slightly higher in treated composites (0.89 g/cm3 for 10% ATBTST), reflecting stronger fiber-matrix interaction. Overall, SC fiber-reinforced LDPE composites demonstrate strong potential as eco-friendly alternatives for non-structural applications.

Keywords: LDPE composites; natural fiber reinforcement; *Sansevieria cylindrica* fibers; surface treatment; sustainable materials

Development of Innovative Slippers with Antimicrobial Upper Layer for Enhanced Hygiene

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Abstract

Maintaining proper hygiene in footwear is essential to prevent microbial growth and associated health issues. This study investigates the development of new slippers through the incorporation of silver nanoparticles (AgNPs) in Technically Specified Rubber (TSR) for enhanced antimicrobial properties. The primary aim was to enhance footwear hygiene by inhibiting microbial growth in regions that are prone to moisture and high usage. The research demonstrates the effective integration of AgNPs into TSR with excellent antimicrobial properties against gram-positive bacteria, including *Staphylococcus aureus*, *Staphylococcus saprophyticus,* and *Pseudomonas* spp., achieving inhibition zones of 10-11 mm at AgNPs concentrations of 0.5-1.5 phr. No antimicrobial activity was observed against *Escherichia coli* and *Klebsiella* spp., indicating the need for further optimization to enhance the material's antimicrobial effectiveness. Fourier transform infrared spectroscopic characterization demonstrated the incorporation of AgNPs into the rubber matrix via peaks attributed to the formation of silver-oxygen bonds. Thermogravimetric analysis revealed that AgNPs enhanced the thermal stability of rubber by delaying its degradation at high loadings. Further, mechanical analysis demonstrated that tensile strength was optimum at 0.5 phr of AgNPs but decreased at higher loadings owing to agglomeration of nanoparticles, while hardness increased by enhancing the durability of the matrix. The incorporation of trisodium citrate as a reducing agent, along with biodegradable TSR, contributes to a more environmentally friendly approach compared to conventional antimicrobial agents, aligning with the principles of sustainable synthesis. This study further presents the potential of these kinds of antimicrobial slippers for healthcare and public settings where hygiene is most critical. Through unscalable processes, this study paves the way for future developments in antimicrobial, eco-friendly footwear.

Keywords: antimicrobial; footwear; rubber nanocomposites; silver nanoparticles; TSR

Eco-engineering of Recycled Polypropylene and Nylon Fiber Composites for Non-structural Applications

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Abstract

Polypropylene (PP) and waste nylon fibers are identified as widely used and environmentally problematic materials. Those matrices pose significant disposal challenges owing to their non-biodegradable nature and frequent incineration. This study focuses on the development of recycled PP–nylon fiber composites, aiming to enhance mechanical performance through surface treatment and offer a sustainable alternative for non-structural applications. The mechanical, thermal, and structural characteristics of recycled PP reinforced with waste nylon fibers, focusing on the impact of surface treatment with 3-Aminopropyltriethoxysilane (APTES), and varying fiber loadings (1, 5, 10, and 15%), were evaluated. This research involved collecting recycled PP and waste nylon fiber from industrial by-products, washing with ethanol, treating with 1% APTES (stir for 40 mins and heat cure at 120 °C for 2 hrs), followed by melt mixing in a heat press to form specimens. Mechanical characterization was performed according to the ASTM standards, including evaluation of tensile strength, flexural strength, impact resistance, compression, and hardness. Further, the chemical interactions and the thermal stability of the specimens were evaluated through Fourier transform infrared analysis and thermogravimetric analysis methods. A significant difference (p<0.05) in tensile strength was obtained for different fiber loading ratios and for surface-treated, recycled samples; 18.5 MPa at 1%, 17.8 MPa at 5%, and 14 MPa at 15%, which was significantly higher than the untreated sample (9.5 MPa at 15% loading) was recorded. Compression tests showed up to a 41% increase in compressive strength owing to surface treatment, while impact strength improved by 80-100% over recycled PP (10 kJ/m^2), with the highest energy absorption (~20 kJ/m^2) observed at 5% fiber loading in both treated and untreated samples. Flexural strength increased with treatment, peaking at 15.7 MPa at 5% loading. Hardness testing values remained largely unaffected by fiber addition but consistently exceeded those of virgin PP (~85.5 Shore A). Further, the results demonstrated that reinforcing recycled PP with APTES-treated waste nylon fibers remarkably enhances its mechanical and thermal properties, approaching or exceeding the performance of virgin materials.

Keywords: recycled polypropylene; waste nylon; surface treatment; eco-composites

Assessing the Suitability of Bamboo Fabrics for the Development of Sustainable Fitted Sheets

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Abstract

Sustainable and innovative materials that not only satisfy consumer demands but also enhance health and well-being are becoming more important to the textile industry. Bamboo has been brought into the spotlight as a replacement for petrochemical-based synthetic fibers, as it is obtained from a plant. Bamboo fiber offers a significant opportunity for sustainable textiles. The purpose of this study is to assess the suitability of bamboo fabrics for the development of sustainable fitted sheets. For this study, different blends of naturally dyed bamboo woven and knitted fabrics, bamboo woven (100%), bamboo cotton fleece (65.10/34.90), and bamboo cotton lycra (66.71/28.41/4.88) were assessed for their suitability for fitted sheets. The selected fabrics were dyed with natural plant dyes such as eupatorium and indigo dye. To assess the properties of the fabrics, a range of mechanical, chemical, and antibacterial tests was conducted. Specially, fabric thickness, weight, pilling resistance, abrasion resistance, bursting strength, water absorption, flammability, color fastness, stain resistance, and antibacterial activity tests were conducted by using ISO, AATCC, ATCC, and ASTM methods, and also the selected fabrics were evaluated visually by ten selected consumers. Knitted fabrics, in particular, are ideal for fitted sheets since they can tightly adjust to different mattress depths and stay tightly in place, and also should have good dimensional stability to maintain their shape after washing, and elasticity to fit snugly around the mattress. The evaluation results indicate that the knitted type of bamboo cotton lycra fabric exhibits superior performance across these metrics. The fabrics exhibited a thickness of 0.66 mm, a bursting strength of 383 kPa, and a color fastness rating of 3-4, and the wettability rate shows five seconds. Notably, the fabric demonstrated good antibacterial properties. The antibacterial test result shows the zones of inhibition of 17 mm against *Staphylococcus aureus* and 16 mm against *Escherichia coli* on the fabric. The findings of the visual evaluation among the fabrics evaluated, the bamboo cotton lycra fabric was perceived by consumers as soft and smooth with good elasticity and flexibility. The study results concluded that bamboo cotton lycra had excellent properties for developing fitted sheets for residential places.

Key Words: bamboo fabrics; sustainability; fitted sheets; *Staphylococcus aureus*; *Escherichia coli*

Effect of Reduced Graphene Oxide as a Reinforcing Filler on the Mechanical and Ageing Behavior of Natural and Synthetic Rubber Blended Rubber Composites

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Abstract

Natural rubber, styrene butadiene rubber, and butadiene rubber blends are commonly used in the rubber industry for their excellent mechanical performance. However, prolonged exposure to sunlight and oxygen causes oxidative degradation, leading to rubber hardening and loss of elasticity. Reduced graphene oxide is a promising nanomaterial that enhances rubber performance due to its strong mechanical strength and bonding with rubber matrices. This study aims to evaluate the effect of reduced graphene oxide on the mechanical behavior of natural rubber, styrene butadiene rubber, and butadiene rubber composite systems before and after thermal ageing. Most studies focused on rGO-reinforced natural rubber, while research on its use in natural rubber-synthetic rubber blends is limited. Five different composites were formulated: a reference compound filled with only carbon black and three nanocomposites incorporating reduced graphene oxide at concentrations of 0.5, 2.5, 5, and 10% by weight. The tensile strength and elastic modulus of the composites were systematically measured to determine the influence of reduced graphene oxide under both unaged and thermally aged conditions. In the unaged state, composites with 2.5 and 5% reduced graphene oxide showed tensile strength improvements of 25.8 and 17.6%, respectively, compared to the reference. Following thermal ageing, these values decreased by 8.5 and 0.24%, respectively. But no significant improvement was observed at 0.5 and 10%. The elastic modulus increased by 16.5 and 59.8% at 0.5 and 2.5% reduced graphene oxide loading before ageing. After aging, the modulus of all compounds increased compared to their unaged values due to additional crosslinking. However, the modulus of the composites containing 0.5 and 2.5% reduced graphene oxide decreased by 6 and 9%, respectively, when compared to the aged reference. Thermal ageing promotes crosslink formation, but reduced graphene oxide helps maintain better flexibility and less deterioration compared to the reference. Its two-dimensional structure and high surface area create an overlapping filler network, enabling the composite to easily deform under stress.

Keywords: reduced graphene oxide; thermal ageing; tensile strength; elastic modulus; nanocomposites; crosslinking behavior

Optimizing Biochar-based Hybrid Fillers for Enhanced Mechanical Properties in Natural Rubber

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Abstract

Carbon black (CB), the dominant reinforcing filler used in the rubber industry, is produced through the incomplete combustion of heavy aromatic oils and is classified as a Group 2B carcinogen, raising considerable environmental and health concerns. Recently, biochar (BC) has emerged as a sustainable alternative to CB, owing to its high surface area and porous structure, making it a promising reinforcing filler in natural rubber composites. This work uniquely explores hybrid filler systems combining CB and BC across multiple particle sizes, elucidating their synergistic effects on mechanical properties in aged and unaged natural rubber. This study investigated the potential of BC, produced from sawdust and crushed pinus feedstock via pyrolysis at a temperature of 700 °C, to reinforce natural rubber vulcanizates. Pyrolysis was conducted at a heating rate of 420 °C per hour, sustained for 2 hours. The effects of three particle size ranges (50-100, 250-500, and 1000-2000 µm) and hybrid filler systems combining CB and BC in ratios of 0:45%, 22.5:22.5%, and 45:0% were evaluated. Mechanical performance of the natural rubber compounds was evaluated under both aged and unaged conditions. Both unaged and aged rubber composites showed a synergistic effect on tensile strength, modulus, and elongation at break. Compared to the reference, as only CB 45 phr, the unaged vulcanizate containing SBC (50-100 µm) and CB at a 22.5:22.5 wt% ratio exhibited a 50% increase in tensile strength. In the aged sample, the same composition resulted in a 35 % increase. The modulus at 100% elongation for the Crushed biochar (CBC)-filled sample (50-100 µm, 22.5:22.5 phr) before aging was recorded as slightly higher than the reference, indicating a 4.65% increase. The highest elongation at break (128%) occurred in the unaged sample filled with CBC (50-100 µm) at a 22.5:22.5 wt% ratio. These results highlight the influence of BC type, particle size, and filler ratio on the reinforcing efficiency in natural rubber composites. The use of BC derived from waste materials offers an environmentally friendly and effective approach for enhancing the mechanical properties of rubber products, such as tyre industry.

Keywords: carbon black; mechanical properties; hybrid fillers; reinforcing efficiency; biochar

Molecular Structure Prediction of Pine Wood-derived Biochar

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Abstract

Biochar, carbon-rich solid material generated through the pyrolysis of biomass at elevated temperatures in an oxygen-limited environment, is widely recognized for its diverse applications, including low-cost adsorbents, soil improvement, and environmental remediation. However, despite its broad utility, there is a limited atomistic-level understanding of the structural characteristics of pine wood biochar, even though pine wood is widely available, contains a higher carbon content, and is highly favorable for pyrolysis. In this study, pine wood biochar produced at approximately 700 ^{0}C was modeled to investigate its molecular structures for sawdust and crushed particles, addressing the limited availability of molecular structure information for pine wood. Pine wood biochar, mainly composed of carbon with minor amounts of hydrogen, oxygen, and nitrogen, was modeled to reflect experimentally derived crystallite dimensions from XRD analysis across particle sizes ranging from 50-100 µm, 250-500 µm, and 1000-2000 µm. The D/G ratio of the pine wood biochar is characteristic of disordered carbon materials and adds the >10% non-hexagonal rings. The voids in the model are less than 2 nm, and the functional groups are assigned based on the empirical oxygen content and FTIR analysis, with major moieties including pyrone, quinone, hydroxyl, and ketone groups. The atomistic model is validated by the DFT-optimized structure at the B3LYP/6-31G+(d,p) level, which is the absence of imaginary vibrational frequencies and verifies the energy minimum. By linking experimental data with computational analysis, this model enables precise prediction and optimization of the structural and functional properties of pine wood-derived biochar.

Keywords: biochar; density functional theory; molecular modelling; pine wood

Thermal Activation of Shape Memory Properties in Thermoplastic Vulcanizates from Recycled ABS and Nitrile Butadiene Rubber for Sustainable Applications

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Abstract

Acrylonitrile butadiene styrene (ABS) polymer is extensively utilized in the plastic industry. A higher amount of cut-off waste is generated during manufacturing processes. This research was focused on the development of sustainable acrylonitrile butadiene styrene (ABS) and nitrile butadiene rubber (NBR)-based shape memory thermoplastic vulcanizates (TPVs) for sustainable applications. A series of blends were formulated in seven different weight ratios ranging from 100% recycled ABS (reABS) to 100% NBR, including critical compositions such as reABS85:NBR15, reABS70:NBR30, and reABS50:NBR50, which were subjected to the characterization process to evaluate recyclability and thermomechanical performance, including tensile, impact, hardness, and flexural tests. Additionally, rheological testing, scanning electron microscopy, thermogravimetric analysis, differential scanning calorimetry, cyclic stress-strain analysis, and shape memory testing were performed. All the testing were conducted according to the relevant ASTM standards. The reABS:NBR blends were processed through multiple recycling cycles using a thermo-mechanical route that involved compression molding at 160 °C and subsequent mechanical breakdown. The reABS85:NBR15 and ABS70:NBR30 composites experienced 10 successive recycling cycles, demonstrating notable mechanical stability. Shape memory performance was evaluated at 110 °C and 180 °C. At 110 °C, reABS70:NBR30 exhibited higher shape recovery (~80%) while maintaining high shape fixity (~83%). At 180 °C, all materials showed nearly perfect shape recovery (~100%), with shape fixity stabilizing around 88%. These results demonstrated that the incorporation of NBR into ABS significantly enhanced shape memory behavior, especially at elevated temperatures. These findings present a viable pathway towards sustainable high-performance polymeric materials with enhanced recyclability, durability, and functional adaptability for advanced industrial applications.

Keywords: shape memory polymers; thermoplastic vulcanizates; material reusability; sustainable materials; acrylonitrile butadiene styrene

Development of Biodegradable Fiber-Natural Rubber Latex Composite Mulch with Slow-release Fertilizer Layer for Sustainable Agriculture plantation

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Abstract

Use of conventional plastic mulch films in agriculture derived from petrochemicals such as LDPE and LLDPE poses threats to the environment. These include soil contamination from microplastics, labor-intensive post-harvest removal, and long-term ecological harm. The present study develops a sustainable biodegradable alternative mulch film using natural fibers and rubber latex, enhanced with a slow-release fertilizer layer. Three natural fibers, including banana, arecanut husk, and sugarcane bagasse, were evaluated as structural components, with natural rubber latex acting as the binding matrix. The effects of fiber type, fiber length, sulfur content in the latex compound, and phosphate to biochar ratios were systematically investigated to optimize the formulation. Mechanical properties were assessed through tensile and tear strength tests, while biodegradability was evaluated over a three-month soil burial period using weight loss measurements and FTIR spectroscopy. Among the tested fibers, sugarcane bagasse emerged as the most suitable for commercial application, offering sufficient mechanical performance and wide availability as an agro-industrial by-product. FTIR analysis confirmed progressive biodegradation, with significant alterations in functional groups related to cellulose and rubber breakdown. Field trials using chili plants demonstrated that mulch incorporating a 2:1 phosphate-to-biochar ratio supported optimal plant growth. Furthermore, microclimate monitoring indicated that the biodegradable mulch effectively moderated soil temperature and retained moisture, outperforming conventional plastic mulch in temperature regulation.

Keywords: biodegradable mulch; natural rubber latex; sustainable agriculture; slow-release fertilizer; natural fibers

Comparative Study of Cellulose Nanocrystals and Bentonite Clay as Fillers in Natural Rubber Latex Thin Films

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Abstract

The environmental impact of single-use disposable gloves, particularly following increased global demand during health emergencies, urged the requirement of development of degradable gloves. This study investigates the incorporation of cellulose nanocrystals (CNC) and bentonite clay (BC) as eco-friendly fillers in natural rubber latex gloves, with the aim of enhancing mechanical performance while improving environmental sustainability. Cellulose nanocrystals and bentonite clay were selected due to their biodegradable properties. Latex films were prepared with varying concentrations of CNC and BC. The chemical and physic-mechanical properties were measured through Fourier transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), particle size analysis, tensile testing, water leakage testing, and biodegradability assessment. FTIR and TGA confirmed the successful integration of the fillers and provided insights into their structural and thermal behavior. The results showed that at low concentrations of these fillers, particularly at 0.1 phr of CNC and 0.5 phr of BC concentrations tensile strength and elongation at break increase significantly compared to the control sample without fillers, which is required by the glove compounds. At slightly higher filler concentrations, such as 3 phr of both BC and CNC, has lower stress at break compared to the previous, but in comparable range with the control sample. Water leakage tests demonstrated that the modified gloves maintained effective barrier properties, ensuring their suitability for protective use. Upon exposure of the rubber samples to the compost, the weight loss of the samples increased with increasing filler content, revealing that both CNC and BC accelerate the glove degradation in soil, with the highest rates observed at 3 phr filler loadings. By comparing the results, both improved mechanical properties and higher biodegradability were observed at 1 phr of BC and 0.5 phr of CNC.

Keywords: cellulose nanocrystals; bentonite clay; biodegradable glove

Development of 3D Printable Ananas Fiber/Thermoplastic Composites for Automobile Applications

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Abstract

The growing demand on sustainability and lightweight materials in the automotive and manufacturing industries persuade research into natural fiber-reinforced polymer composites. This study focuses on the development and characterization of thermoplastic (TP) polymer-based composites reinforced with ananas fiber, targeting potential applications in non-structural automotive components and fused deposition modeling-based 3D printing. Ananas fiber is a widely available agricultural waste with better physical and mechanical properties. In this research, ananas fibers were mechanically extracted and prepared in two forms: untreated and chemically treated. Chemical treatment was carried out using sodium hydroxide and sodium hypochlorite. Using the heat press method, at 220 °C, composite samples were prepared by varying weight percent (wt%) fiber loadings in the TP matrix to yield 1, 3, 5, 7, and 10 wt% of fiber in TP. Neat TP was used as the control. For both treated and untreated composites, impact strength was increased with fiber loading, while density was reduced, resulting high-impact resistant light-weight materials. Moreover, the composite with the lowest fiber loading (1 wt%) showed successful filament-based 3D printability, resulting a 3D square-shaped panel. This research provides new insights into the sustainable use of agricultural waste for advanced manufacturing. By demonstrating the viability of ananas fiber-reinforced TP composites for 3D printing and light-weight automotive applications, the study contributes to the broader goals of promoting eco-friendly materials and advancing polymer composite technologies.

Keywords: thermoplastic composites; 3D printing; ananas fiber; sustainability; automobile applications

Optimization of a Shoe Sole Compound Replacing High Styrene Resin with Waste Low-density Polyethylene for Enhanced Mechanical Properties and Cost Efficiency

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Abstract

This study investigates the optimization of a shoe sole compound by replacing high styrene resin (HSR) with waste low-density polyethylene (LDPE) to enhance mechanical properties and cost efficiency. The research aimed to develop a sustainable and cost-effective shoe sole material by blending styrene-butadiene rubber with waste LDPE, addressing environmental concerns associated with plastic waste. Fifteen formulations with varying LDPE content (2.5 to 37.5%) were prepared and tested for tensile strength, tear strength, hardness, volume loss, elongation at break, and flexural resistance. Results indicated that replacing up to 10% HSR with LDPE (the S4 formulation) maintained acceptable mechanical properties, including tensile strength (75 MPa), tear strength (4.0 N/mm), hardness (92.2 IRHD), elongation at break (321.5%), and volume loss (0.1 mm^3) while reducing material cost by 17%. Higher LDPE concentrations (>15%) led to significant declines in tensile strength, tear resistance, and volume loss, though flexural resistance remained unaffected across all samples. The S4 formulation demonstrated the best balance between performance and cost, making it suitable for the industrial application. The conventional formula, the control, costs around rupees 753.97/kg. However, the prepared S4 sample is more cost-effective at rupees 624.53/kg due to the addition of cheap LDPE. Furthermore, the S4 sample lowered the cost without leading to major changes in properties. Overall, the study highlights the potential of incorporating waste LDPE as a sustainable alternative in the shoe sole production, contributing to waste reduction and cost savings without compromising critical mechanical properties.

Keywords: waste; low-density polyethylene; high styrene resin; cost efficiency; shoe sole compounds

Thermal and Mechanical Properties of 3D Printed Cellulosic Fiber/Thermoplastic Thermal Insulation Panels

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Abstract

Research toward eco-friendly thermal insulation solutions has increased with the increasing demand for sustainable building materials. Most traditional synthetic insulation materials have petroleum-based origins, and their non-biodegradable nature has posed environmental concerns. Natural fiber-reinforced polymer composites offer promising alternatives for sustainable thermal insulation applications. This study aimed to develop and characterize 3D-printable thermal insulation panels using natural cellulosic fiber (CF) reinforcement in a thermoplastic (TP) polymer matrix. The thermal insulation properties, mechanical performance, and 3D printability of the composites were evaluated. The fibers were extracted mechanically from collected plants and processed into powder form. Virgin thermoplastic (vTP) was used as the control. Composites were fabricated with weight percent (wt%) fiber loadings ranging from 10 to 40 wt% in the TP matrix using the heat press method at 180 °C. Increasing fiber content decreased the hardness from 90.68 to 74.15 Shore D. However, impact strength increased from 65.53 to 71.6 kJ/m², demonstrating enhanced energy absorption. Thermal conductivity decreased at 20 wt% CF loading (~0.22 W/m·K). Furthermore, successful filament-based 3D printing was achieved with the 10 wt% CF and 20 wt% CF loaded composites, yielding 3D panel-shaped structures. The source of the selected cellulosic fiber was a natural aquatic weed. Therefore, while offering environmental benefits through the utilization of a problematic aquatic weed, the 20 wt% CF-loaded composite demonstrated an optimal balance between the thermal insulation properties and mechanical performance. Moreover, the 3D printability of the material paves the way for future innovative manufacturing approaches for customized insulation panels, contributing towards sustainable building materials.

Keywords: natural fiber-reinforced composites; thermal insulation; 3D printing; sustainable building materials; aquatic weed

Recycled Glass Fiber Reinforced Thermoplastic-based 3D Printable Composites for Boating Application

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Abstract

The marine industry faces mounting environmental challenges from end-of-life fiberglass boat components, which are predominantly landfilled or incinerated due to the non-biodegradable nature of thermoset composites. This study presents a sustainable circular economic solution by developing recycled glass fiber (RGF)-reinforced thermoplastic (TP) composites for fused deposition modeling (FDM)-based 3D printing applications. Scrap boat parts were mechanically ground and sieved to obtain RGF with controlled length distributions (0.4 mm), followed by compounding with the thermoplastic at 1, 3, 5, and 10 weight percent (wt%) of RGF loadings. Neat TP was used as the control. Composite specimens and 3D printing filaments were fabricated to evaluate mechanical properties and 3D printability. Experimental results demonstrated a complex interplay between fiber content and performance. Tensile strength decreased incrementally from 28.1 MPa (control) to 22.0 MPa (10 wt% of RGF in TP) due to interfacial stress concentrations and subcritical fiber lengths. However, compressive strength improved by 4.3% (125.5 MPa) at the maximal RGF loading (10 wt% of RGF in TP). In the same composite, impact strength was also increased by 7.7% while Shore D hardness peaked at 72.2, attributable to fiber-induced load distribution. The resulting density values slightly varied with the RGF content (1.145-1.238 g/cm^3), reflecting effective void reduction. Furthermore, successful FDM-based 3D printing of the lowest RGF-loaded specimens using a 0.4 mm diameter nozzle validated the additive manufacturing processability of low-fiber-loaded composites. This work demonstrates that mechanically recycled RGF can be effectively composited with 3D printable TPs to yield value-added structures applicable in boating and other automobiles.

Keywords: 3D printing; thermoplastic; mechanical recycling; fiberglass; boating applications

Development of a 3D Printable Shape Memory Composite using Polyvinyl Chloride and Polyurethane

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Abstract

The growing demand for sustainable and cost-effective materials in 3D printing has led to the exploration of waste-based composites as viable alternatives to traditional filaments. This research investigated the development of 3D printable composites using waste thermoplastic materials, with a focus on improving the mechanical properties and printability of the material. The objective of this study was to enhance the material properties of the composites by blending two thermoplastic materials, creating a composite filament suitable for fused deposition modeling-based 3D printers. The study first examined the mechanical properties of the composites, including tensile strength, impact resistance, hardness, and compression strength. Two series of composites were prepared by combining different weight percentages (wt%) of polyurethane (PU) with virgin polyvinyl chloride (PVC) and waste PVC separately. Virgin PVC and waste PVC were denoted as control-1 and 2, respectively. The resulting materials were evaluated for their suitability in 3D printing applications. Also, shape memory properties were tested to choose the best composition of the blend. Furthermore, the work identified the challenges in printing the composites, including nozzle clogging and material adhesion to the print-bed. By optimizing the printing parameters, such as print temperature, the study successfully minimized nozzle clogging, but material adhesion to the print-bed was poor. However, according to the results, the waste PVC (control-2) showed the maximum tensile strength (32 MPa), impact strength (68 kJ/m), hardness (72 Shore D), and compression strength (159 MPa). But the sample of 90 wt% waste PVC/10 wt% PU showed the best shape memory properties. Future work should focus on exploring additional material properties, further improving the printability, and investigating other waste materials for inclusion in the composite to enhance sustainability and performance.

Keywords: shape memory composites; value added waste sustainability; 3D printing; polyurethane

3D Printable Thermoplastic Elastomer Composites Reinforced with Natural Fibers

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Abstract

In the pursuit of sustainable and high-performance materials, this research investigates the development of a natural fibre-reinforced thermoplastic elastomer composite using a thermoplastic (TP) material and elastomer for thermal insulation panel applications. The TP used was derived from renewable resources, offers high strength but suffers from brittleness and limited thermal insulation capacity. To overcome these drawbacks, an elastomer was incorporated into the TP matrix to introduce the elastomeric behavior, improving flexibility, toughness, and impact resistance. An abundant, biodegradable, and cellulose-rich natural fiber reinforcement was also added to further enhance the mechanical strength and reduce the thermal conductivity of the blends. The blend of 80 weight percent (wt%) TP/20 wt% fiber was used as the control. Composites were prepared using melt blending followed by hot press molding, with multiple formulations containing varying elastomer loadings (2, 4, 6, 8, and 10 parts per hundred rubber (phr)). The molded samples were characterized for density, hardness, tensile strength, impact strength, compression strength, and thermal conductivity. Thermogravimetric analysis confirmed that the thermal stability of the composites was up to ~300 °C while differential scanning calorimetry revealed the melting range of the semi-crystalline TP matrix was between 160-170 °C. The presence of cellulose and hemicellulose groups of the natural fiber was verified by Fourier Transform Infrared Spectroscopy. The composite containing 4 phr of elastomer resulted in the highest average mechanical properties; impact strength (68.9 kJ/m), tensile strength (30 MPa), hardness (78.3 Shore D), and density (1.274 g/cm^3). Furthermore, composites containing 2, 4, and 6 phr of elastomer were successfully 3D printed via the fused filament fabrication technique. The study demonstrated the successful fabrication of 3D printable, cost-effective, flexible, and biodegradable thermoplastic elastomer composites. Furthermore, the resulting composites are targeted towards non-structural thermal insulation panels in construction and industrial applications.

Keywords: thermoplastic elastomer; sustainability; 3D printing; natural fiber

Development of 3D Printable Thermoplastic/Carbon Black Filaments with Improved Mechanical Properties

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Abstract

Fused deposition modeling 3D printing faces limitations due to anisotropic mechanical properties caused by weak interlayer bonding and void formation in printed components. This study addresses these challenges by developing thermoplastic (TP)-based composites reinforced with carbon black as a filler to enhance tensile strength and interlayer adhesion. The research focused on optimizing carbon black loading (5%, 10%, and 15% by weight in the TP matrix) and evaluating the mechanical performance of 3D printed specimens along X- and Y-axis orientations. Virgin TP was used as the control. Composite filaments were fabricated via heat press method, to yield custom square-shaped filaments with a 1.5 mm^2 cross-section, designed to approximate the standard of 1.75 mm circular filaments. Thermogravimetric analysis confirmed that the thermal stability of the control was up to 300 °C. Tensile testing revealed that the control exhibited the highest tensile strength of 40.84 MPa along the X-axis and 37.9 MPa along the Y-axis. The 5 wt% composite maintained comparable Y-axis strength of 35.8 MPa but reduced X-axis performance to 31.28 MPa. Higher carbon filler content (10 wt%) significantly degraded tensile strength in both orientations (27 MPa/X-axis, 21.2 MPa/Y-axis), highlighting a critical threshold for filler efficacy. Modulus values similarly declined with carbon black addition, particularly along the X-axis (3375 MPa to 1567 MPa). However, strain and toughness displayed directional dependencies: 5 wt% composite improved Y-axis ductility (2.25% strain) and energy absorption (55 kJ/m^3), whereas the 10 wt% sample diminished these properties. Filament incompatibility, air bubbles, and printing defects were some of the challenges. The study concluded that the 5 wt% filler content offered a viable balance for enhancing toughness and strain in the Y-axis-oriented prints, though higher concentrations compromised mechanical integrity. These findings emphasize the interplay between filler content, print orientation, and material performance, providing actionable insights for developing sustainable, high-performance 3D printing materials.

Keywords: interlayer adhesion; thermoplastic; 3D printing; anisotropic properties; carbon black

3D Printable Natural Fiber Reinforced Thermoplastic Composite for Automobile Applications

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Abstract

This research investigated the development of a 3D printable composite using natural fibers as the reinforcement within a thermoplastic matrix, targeting automotive interior applications. The study was focused on optimizing fiber treatment and loading to enhance the mechanical, thermal, and physical properties of the composite. Natural cellulosic fibers were mechanically extracted and prepared in two forms: untreated and chemically treated. Chemical treatment was carried out using sodium hydroxide and sodium hypochlorite. Using the heat press method, at 240 °C, composites were prepared by blending the powdered thermoplastic (TP) with natural fiber powders at different weight percentages (wt%) of 1, 3, 5, and 7% of fiber in the TP matrix. Neat TP was used as the control. For both treated and untreated composites, impact strength was increased with fiber loading while density was decreased, resulting in high-impact resistant light-weight materials. In fact, the impact strength reached a maximum of 67.0 kJ/m² in the 7 wt% of chemically treated fiber loaded composite, while the lowest density of 1g/cm³ was shown by the 7 wt% untreated fiber loaded sample. Furthermore, all the tested mechanical properties were higher with the chemically treated fiber-loaded composites with respect to their untreated counterparts. Moreover, the composite with the lowest fiber loading (1 wt%) showed successful filament-based 3D printability, resulting in a 3D square panel. Overall results demonstrated that incorporating chemically treated natural cellulosic fibers significantly improved the composite's mechanical performance and thermal stability while maintaining good 3D printability, making it a promising and sustainable alternative for eco-friendly automotive interior components.

Keywords: 3D printable composite; natural fibers; mechanical properties; thermoplastic; automotive interior applications

Mechatronics, Robotics, and Automation

Smart Dance Shoes with Machine Learning Powered Light and Motion Synchronization

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Abstract

In the era of wearable technology, integrating machine learning into performance arts opens new dimensions for user interaction and creativity. This project presents the development of smart dance shoes that utilize motion sensors and machine learning algorithms to deliver real-time RGB light synchronization based on dance movements. The system is built using the ESP32-S3 microcontroller and the MPU 6050 sensor, which capture accelerometer and gyroscope data from the dancer's movements. These data inputs are processed through a machine learning model developed on Edge Impulse, which classifies different dance gestures such as jumps, spins, and steps and triggers corresponding lighting effects to enhance visual performance. The hardware is designed to be lightweight, portable, and user-friendly, making it suitable for dancers, performers, and fitness enthusiasts. Key components include RGB LED neon strips, a 3.7V LiPo battery, and Bluetooth integration for wireless customization. Testing covered unit, integration, and performance evaluations to ensure stability, low latency, and energy efficiency. Future improvements include multi-shoe synchronization, music-responsive lighting, and advanced models such as LSTM. This project demonstrates the potential of intelligent wearables in enhancing interactive and immersive experiences in performing arts.

Keywords: wearable technology; machine learning; motion recognition; RGB lighting; smart dance

AI-integrated Underwater Surveillance Robot for Aquatic Life Monitoring and Water Quality Assessment

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Abstract

The increasing number of fish farms worldwide faces many problems, such as labor shortage, high operational cost, difficulty in monitoring and maintenance, water contamination, high acidity levels, fish illness, and high population density. The main objective of this study is to design and implement a smart, real-time water quality monitoring and management system for aquaculture using Internet of Things (IoT) and Artificial Intelligence (AI) technologies. The system integrates pH, turbidity, underwater ultrasonic, and temperature sensors connected to an ESP32 microcontroller programmed using C++ and ESP-IDF. A design-build-test approach was adopted, where sensor calibration, data acquisition, and cloud-based analysis were performed at hourly interval to validate system performance. Data were transmitted via SIM800L and GPS modules to Google Sheets and Firebase for real-time visualization and storage, and the system was linked to both a webpage dashboard and mobile application for remote monitoring. Experimental evaluation demonstrated reliable wireless communication, accurate sensor readings within ±2% error, data uploading within 500 ms, and stable cloud synchronization. AI and ML algorithms were applied to analyze data, detect anomalies, predict water quality variations, and recommend corrective measures. This solution introduces a modular underwater monitoring platform with wireless and wired communication, enhancing automation, scalability, and sustainability in aquaculture management. Overall, the project effectively minimizes labor, cost, and time while ensuring maximum yield and a healthier aquatic environment.

Keywords: fish farm monitoring; underwater surveillance robot; real-time data; web-based application

Detection of Diseases and Nutrient Deficiencies in Tomato Crops: Computer Vision and Machine Learning Enabled System

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Abstract

This study presents the development of an automated system for detecting diseases and nutrient deficiencies in tomato crops in indoor settings. It supports sustainable agriculture and early management of crop health. The system integrates computer vision and machine learning technologies into a custom-built autonomous robot. It was equipped with a Raspberry Pi with a Pi camera module v2 for image processing and an Arduino Mega for navigation and control. The robot was driven by a line-following mechanism integrated with the Raspberry Pi. The captured image frames were first preprocessed using color-based filtering and masking techniques. Then, they were sent to the YOLOv5n model, which was deployed on the Raspberry Pi. The detected regions were cropped and sent to a Flask-based web application using an HTTP POST request through a local Wi-Fi client-server architecture. There, classification was performed using the MobileNetV2 model. The web application provides actionable insights to farmers based on the identified disease or nutrient deficiency. Furthermore, the detected locations were marked along the robot's path. Additionally, a manual analysis option ensures continuous monitoring. The YOLOv5n model, evaluated against the YOLOv8n model, achieved a precision of 0.6541, a recall of 0.5979, and a mAP@0.5 of 0.6353. Furthermore, the model exhibited a lower validation box loss of 0.0153 and class loss of 0.0013. The MobileNetV2 model was selected after comparison with the custom CNN, EfficientNetB0, and InceptionV3 on several classification tasks. It provided consistent performance with an average accuracy of 91.33% and an average validation loss of 0.32. It exhibited an inference speed of 5.93 FPS, a latency of 138.94 ms, and a very low model size. The model was further trained on 24 classes and achieved 90.00% accuracy and 0.05 validation loss. Real-world tests have proven the practical applicability of this system in controlled environments.

Keywords: tomato crop monitoring; deep learning; transfer learning; autonomous robot; web application

Design and Development of a Modular Mushroom Farming System with Machine Learning-based Crop Management and Yield Forecasting

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Abstract

This study presents the design and development of a portable modular smart farming system tailored for oyster mushroom cultivation, addressing critical challenges faced by small- and medium-scale mushroom growers in Sri Lanka, including poor disease diagnosis, inconsistent yields, and labor-intensive monitoring. Traditional methods rely on manual processes and visual assessments, which limit efficiency, scalability, and predictability. To overcome these limitations, the proposed system integrates IoT-enabled sensors, automated environmental control, and edge AI-based image analysis for real-time monitoring and decision-making. The system utilizes DHT22 sensors to regulate temperature and humidity, LDR sensors to monitor light intensity, and a CO_2 sensor for ventilation control. The environmental parameters were effectively maintained at the optimal ranges of temperature (24-27 °C), humidity (85-95% RH), light intensity (0-500 lux), and CO_2 concentration (<500 ppm), demonstrating over 90% control consistency during continuous cultivation cycles. These controlled parameters significantly improved the fruiting and quality of oyster mushrooms, with precise environmental responses coordinated through Arduino-controlled relay modules and a refrigeration system based on the vapor-compression cycle. An ESP32-CAM mounted on a motorized X-Y gantry captures high-resolution images, which are processed by two custom-trained YOLOv8-based models: one for early disease detection and another for growth stage classification and yield estimation. The disease detection model achieved an overall mAP@0.5 of 79.1% and an overall mAP@0.5:0.95 of 67% on the validation data set (620 images), while the growth stage classification and yield estimation model reached an overall mAP@0.5 of 47.2% which needs more balanced annotations. Further, the developed mobile-accessible flask-based web interface supports real-time user interaction and visualization of prediction results. This modular system, designed for smallholder applications, significantly reduces operational costs compared to commercial mushroom setups and is expected to be further enhanced through cloud integration, cross-crop adaptability, and improved data-driven accuracy.

Keywords: deep learning; IoT monitoring; modular farming system; yield forecasting; mushroom disease detection

Design and Development of an Overmolding Machine for Manufacturing Waterproof Sockets of Automotive Wire Harness Clips

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Abstract

The quick development of automotive electrical systems has increased the demand for durable and weather-resistant wire harness clips. Overmolding technology is a very suitable solution for high-strength, reliable, and waterproof component manufacturing. But commercial overmolding machine is high-cost and complex. Therefore, it is a barrier for small and medium-scale automotive manufacturers. This research project focuses on the design and development of a low-cost semi-automated overmolding machine to produce waterproof sockets in automotive wire harness clips. The study starts with the identification of current molding technologies and limitations in current practices, especially regarding material waste and imprecise process control. The proposed machine has a piston-type injection mechanism, a mold fixing unit, and a PLC-based control system and HMI control for user collaboration. The mechanical and thermal characteristics of PA66 and Santoprene TPV are the materials that were chosen for use in automotive applications. FEA Simulation, CAD modelling, and methodological prototyping were used to optimize the machine parts for manufacturing the machine and identify the performance. The control system provides safe, dependable, and repeatable overmolding cycles. This machine has both manual and semi-automated operations. After the final testing of the system's efficiency in lowering material waste, consistency, and producing high-quality overmolded parts.

Keywords: overmolding; waterproof sockets; automotive; wire harness; molding

Development of IoT-based Patient Monitoring System for Rehabilitation after TKR Surgery

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Abstract

This paper presents the design and evaluation of "PhysioHelp", a remote patient monitoring system to support rehabilitation after Total Knee Replacement (TKR) surgery. It addresses limitations in traditional postoperative care, such as reliance on clinical visits, subjective reporting, and delayed complication detection. The system provides continuous, objective, and personalized monitoring using a Body Sensor Network (BSN) comprising a smart knee brace with dual inertial measurement units (IMUs) and foot insoles embedded with four force-sensitive resistor (FSR) sensors per foot. These sensors collect real-time data on knee angles and plantar pressure, transmitted wirelessly via the MQTT protocol to a Flask backend with MySQL storage. Evaluation involved healthy volunteers performing standard TKR exercises and walking tasks, including ankle pumps, bed-supported knee bends, idle laying on bed, knee straightening exercises, quadriceps sets, sitting supported knee bends, sitting unsupported knee bends, and straight leg raises. The system accurately captured knee joint angles, accelerations, gyroscopic data, and pressure distributions, with angle deviations remaining under three degrees compared to manual readings. The system latency was reduced to below 250 ms. Analysis of the collected data produced heat maps showing force distribution and time-series plots of joint angles, which provided valuable insights into exercise performance. These visualisations allowed patients to observe and correct their own movements, promoting better rehabilitation adherence. Physiotherapists could access this data in real time, enabling them to assess exercise quality remotely, provide targeted feedback, and detect potential complications such as incorrect muscle activation patterns. Results demonstrate reliable biomechanical monitoring and effective multimodal feedback in a user-friendly setup. PhysioHelp shows strong potential to improve TKR rehabilitation by enabling continuous monitoring, enhancing feedback quality, and supporting patient adherence. Future work should focus on clinical testing with TKR patients, hardware and software refinement, and integration with commercial wearables and health records.

Keywords: total knee replacement rehabilitation; remote patient monitoring; body sensor network

Automated System using Computer Vision and Deep Learning for Sorting, Cleaning, Waxing, and Grading of Mango Fruits

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Abstract

Post-harvest management is a critical part of the agricultural supply chain, especially for perishable fruits like mangoes (*Mangifera indica* L). This study introduces an automated system for sorting, cleaning, waxing, and grading mangoes (Karutha Colomban) to solve the problems linked to traditional labor-intensive methods. The project aimed to detect post-harvest damage on mangoes and sort them based on ripeness and shape using deep learning techniques integrated with a conveyor-based system. The system employed a roller conveyor mechanism to transport mangoes through a lighting box for high-quality image capture. The VGG16-based deep learning model, fine-tuned within a multi-task learning framework, demonstrated high precision in classification tasks, achieving an accuracy of 69.68% for ripeness detection and an accuracy of 82.35% for damage identification (1109 images: 80%-training and 20%-testing). The mechanical aspect of the system features a roller conveyor powered by DC motors, while proximity sensors ensure smooth mango movement through various stages. Cleaning operations efficiently removed 80% of surface contaminants. Meanwhile, the waxing mechanism applied a uniform edible coating on 85% of mangoes, significantly extending their shelf life. The mechanical grading system sorted mangoes by size with an accuracy of 88%. Moreover, a user-friendly graphical user interface was created using Streamlit, allowing for real-time monitoring and operational control. The seamless integration of hardware and software, managed by Raspberry Pi and Arduino, enabled smooth communication and automation throughout the processes. These results underscore the potential of the system to improve post-harvest processing efficiency and quality in real-world agricultural settings, providing a scalable and cost-effective solution for small and medium-sized farmers. Expanding the dataset to include a more diverse range of mango varieties, defects, and environmental conditions would improve the model robustness and generalization.

Keywords: computer vision; deep learning; mango sorting; post-harvest automation; VGG16 architecture

Extended Reality-enhanced Human-machine Interfaces: Evaluating Implementation Strategies and Methodologies for Industrial Control Systems

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Abstract

The evolution of Human-machine Interface systems (HMIs) in industrial automation has reached a critical point where it gives immersive interaction between the user and the machine. Traditional panel-based systems that come with touchscreen interfaces have some limitations in spatial understanding, operator efficiency, and cognitive load management. This paper represents a design methods and framework for implementing advanced Extended reality (XR) technology as a next-generation HMI solution tailored for industrial automation systems. This research focuses on designing, developing, and validating an XR-based control interface for industrial automation with the thermal management and automation system as a case study, where the system uses Meta Quest 2 VR headset integrated with Unity's XR Interaction Toolkit and a robust digital twin architecture. The designed system architecture contains a multi-layered approach that compacts SolidWorks-based 3D modeling, Unity Game Engine-based VR application and environment development, and Blender-based 3D model optimization pipeline. This creates immersive control experiences for industrial automation systems. The performance evaluation shows significant improvements in operator interaction. The implemented system could be able to achieve the real-time synchronization between physical and virtual systems with latency of near 200 ms and maintain consistent frame rates above 72 fps on commercial VR hardware for Meta Quest 2 VR headset. The multi-layer safety architecture ensures industrial-grade reliability while providing clear emergency response protocols through immersive VR interfaces like emergency stop, etc. It contained minimal motion sickness effects, proving the system is viable for extended operational sessions in industrial environments.

Keywords: extended reality; digital twin; human-machine interface; industrial automation; virtual reality

Science for Technology

Nanotechnology Driven Biodegradable Membranes for Wound Management; Electrospun PCL Nanohybrids with Trimetallic and Curcuminoids Synergy

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Abstract

The increasing risk of microbial infections and antimicrobial resistance requires new materials that have multifunctional therapeutic characteristics. This study aimed to incorporate curcuminoids and trimetallic nanohybrid (Ag, Cu, and Ni) in the electrospun nanofiber membranes fabricated using biodegradable polycaprolactone (PCL) to achieve efficacy in antibacterial and anti-inflammatory response. With its contribution to nanomedicine and materials science, this project mainly benefits biomedical applications, primarily wound care. Curcuminoids were extracted from turmeric oleoresin, and their characteristics were verified through TLC, FTIR, and XRD. Synthesis of metallic nanoparticles was performed via the chemical reduction method with the addition of ascorbic acid to stabilize the particles, and then analyzed by FTIR, Raman spectroscopy, XRD, SEM /EDX, and UV-Vis diffuse reflectance. These were incorporated into PCL through electrospinning for the fabrication of nanofiber mats. This fabricated membrane exhibited strong antimicrobial, antioxidant, and anti-inflammatory activity against a broad spectrum of microorganisms. Antimicrobial testing by MIC, MBC, MFC, and IC_{50} assays showed that the combination of trimetallic-curcuminoid had better inhibitory activity compared to each of its components. Analysis with SEM and EDX showed the morphological characteristics and elemental composition in the nanofibers. In release studies, the system kept a slow and sustained release of curcuminoids being released in a constant way, as the release mechanism fitted into a zeroth-order kinetic model, which is good for a continuous, long-term treatment. Because of these factors, the membrane is able to keep preventing microbial growth at the site it is used. All in all, the trimetallic + curcuminoids incorporated PCL membrane is a promising type of biomaterial that is helpful for many purposes, affordable, and friendly to the environment. The wide-ranging ability to fight infections and steady drug release, along with tolerance to wound pH, make it a possible candidate for advanced wounds and upcoming biomedical materials.

Keywords: antimicrobial; anti-inflammatory; curcuminoids; electrospinning; trimetallic nanoparticles

Machine Learning Approach to Reduce Lead Ball Artifacts in Pelvic CT Images

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Abstract

Lead balls are used as fiducial markers for External Beam Radio Therapy planning during the process of Computed Tomography (CT) simulation. These introduce high-density artifacts that distort anatomical details, potentially affecting dose calculations and treatment quality. This study focused on a machine learning based approach to detect and reduce such artifacts in the pelvic CT image series of patients using a four-layered U-Net-based encoder-decoder model. The input dataset consisted of pelvic CT image series from 220 patients, including around 670 image slices identified to contain artifacts, along with corresponding artifact-free images and binary masks indicating artifact regions. The model was trained and validated to identify and inpaint the artifact-affected regions using details of the surrounding pixels of the images. The performance of the trained model was evaluated on a separate, previously unseen test data set of twenty images, and the results showed an average peak signal-to-noise ratio value of 37.58 dB and a structural similarity index of 0.9888. The results showed that the model can effectively reconstruct clean images from artifact-containing images. This method provided a scalable automated solution for lead markers-induced artifacts in computed tomography images with a potential applicability in artifact correction in a broader range of radiography and radiotherapy.

Keywords: CT artifacts; image inpainting; lead ball artifact; medical imaging; U-Net-based inpainting

Optimization of Iodine Separation from Irradiated ^{130}Te by Wet Distillation Method by Using Irradiated KIO_3 as an Alternative

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Abstract

^{131}I can be produced by neutron activation of ^{130}Te. When ^{130}Te captures a neutron, it converts to ^{131}Te, which then beta decays into ^{131}I while emitting both beta and gamma radiation. However, after irradiation, the resulting ^{131}I remains mixed with other Te isotopes which require a chemical separation step. One of the proven approaches is wet distillation, in which the Te is dissolved in an acidic solution, added 30% H_2O_2, heated to distil off ^{131}I, and captured in a mixture of NaOH and $Na_2S_2O_3$ as NaI. Before the final ^{131}I separation, it is important to optimize the chemical procedure to get the highest yield of ^{131}I. KIO_3 was used as an alternative to optimize the capturing of iodine. A KIO_3 sample was prepared by dissolving 5 g of KIO_3 in 20 mL of an aqua regia, then irradiated in the neutron activation facility. Following irradiation, 1 mL of 30% H_2O_2 was added to the sample in the distillation flask, and a wet distillation was performed, and the iodine activity in the trapping medium was measured using a sodium iodide detector. This procedure was systematically repeated across a series of samples with varying volumes of 30% H_2O_2. The separation efficiency was calculated and plotted as a function of H_2O_2 volume. The optimal oxidant volume that maximized the iodine trapping was 3 mL. Different volumetric mixtures of NaOH and $Na_2S_2O_3$ were prepared for different pH values. Each mixture was tested as a trapping medium, and the iodine collected was measured. The optimal pH for iodine trapping was found to be 9.5. Using the optimized reagent volumes identified earlier, the separation process successfully isolated ^{131}I from Te with an efficiency of 59% which proved the ability to use an alternative compound for optimization of a procedure to get the highest iodine yield.

Key words: neutron activation; wet distillation; radio iodine separation; optimization

Study of Photonic Crystal Fiber Structures for Enhanced Surface-enhanced Raman Spectroscopy (SERS) Applications

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Abstract

Photonic crystal fibers (PCFs) provide superior light confinement and tunable guidance properties, making them promising candidates for surface-enhanced Raman spectroscopy (SERS). This study investigates PCF structures with larger mode field diameter (MFD) and enhanced power fraction using finite element method simulations in COMSOL Multiphysics. Four structural patterns were analyzed: (i) varying consecutive hole diameters in the first ring, (ii) modifying hole-to-pitch ratio, (iii) increasing the number of hole rings, and (iv) varying hole diameters across multiple rings. Simulation results reveal that fractional power is highly sensitive to hole-to-pitch ratio, while layered modifications affect both field confinement and stray propagation. Pattern 2 provides the best improvement in fractional power, whereas Pattern 4 supports stronger stray field propagation beyond MFD. These findings indicate that careful optimization of PCF geometry enhances its performance for SERS, enabling practical applications in biomedical and chemical sensing.

Keywords: photonic crystal fiber; surface-enhanced Raman spectroscopy; finite element method; mode field diameter

Technology Education and Management

The Role of Artificial Intelligence Tools in Transforming Education in Sri Lanka

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Abstract

The integration of educational technology, especially in Artificial Intelligence (AI) tools, has gained significant place in Sri Lankan education institutions, reshaping how teaching and learning and institutional management are conducted. This research investigates the impact of AI-driven platforms and tools such as intelligent tutoring systems, learning analytics, and automated content generation on teaching effectiveness, student engagement, and administrative efficiency. Focusing on the implementation tools like ChatGPT, Google Classroom, and AI-based assessment systems. The study employed a mixed-method approach with quotative surveys from 100 educators and qualitative interviews with 15 academic managers across five districts. Findings highlight that while AI technologies offer substantial benefits in personalizing learning and streaming academic flows, challenges persist in digital literacy, data privacy, and institutional readiness. Schools and universities with clear AI integration strategies, ongoing staff training, and infrastructure support demonstrated significantly high success in implementation. The paper concludes that to harness the full potential of AI in education, institutions must adopt a comprehensive management approach combining policy development, professional development, and investment in AI infrastructure, ensuring equitable access and sustainable impact.

Key words: technology integration; artificial intelligence; digital learning; education management; education technology; learning analytics; mixed-methods

Assessment of Digital Competency of Students as a Key Indicator for Technology-enabled Education: A Case Study in Sri Lanka Institute of Advanced Technological Education

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Abstract

The ICT is considered an umbrella for today's communication and education, especially in online education, distance learning, blended learning, and as an education solution for pandemic situations. In this context, digital competency and digital portfolio of students should be considered as a key requirement in learning. This study focused on analyzing of digital competency of higher educational students as there is very few literature on the topic, particularly in the Sri Lankan situation. The digital competency of students was investigated following the 'General Technology Competence and Use Model' introduced by Francois Desjardins, which has four dimensions, namely technical, social, informational, and epistemological competency. The Blayone instrument was employed, and primary data were gathered via an online distributed pre-tested survey questionnaire. The study collected data from randomly selected 50 agriculture students who follow the Higher National Diploma program in ABC institute. Inferential and descriptive statistics were employed to analyze the data. According to the results, the sample consisted of 62% of female students, and most of the respondents were in the average monthly income category. Among the respondents, 84% owned at least one technological device. The most popular device was smartphone. While digital competency was investigated using the percentage of competent students, the results showed that the majority (68%) were at a moderate level of digital competency. The study found the relationship between confidence and frequency of applying the above four dimensions through a valid linear regression model (R^2=0.398) and discovered that frequency is a significant causal factor for the confidence of these activities (F=31.05, $p \geq 0.01$). Therefore, the model was represented as 'Confidence=9.1+0.85 Frequency'. The study implicated that the students could be provided with prior ICT skill development programs, which can help them to easily do their digital activities and provide some grants, such as easy payment-based purchases, installment purchases, work and pay basis to obtain their own ICT resources are mandatory with the ICT skill development programs to enhance the digital competency of the students.

Keywords: digital competency; education; ICT; on-line education

Evaluating the Readiness and Impact of E-commerce on Coastal Communities: A Study on Skill Development and Employment Opportunities in the Negombo Coastal Area, Sri Lanka

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Abstract

The research evaluates the readiness and effect of e-commerce on the coastal communities of Sri Lanka, especially Negombo, skill development, and employment opportunities. Traditionally reliant on fishing and tourism, these communities now face opportunities and challenges. The research draws attention to the local perception towards digital literacy, understanding skill gaps, and assessing infrastructure requirements for proper integration. A structured questionnaire was administered to 200 residents aged 18 and above, stratified into 3 age groups to measure different aspects regarding awareness of e-commerce, digital literacy levels, as well as skills development needs. The results indicated a rising divergence between possession and utilization of internet-enabled devices. While 85% owned an access device, only 65% were actually using it for online services. In addition, 70% of the participants accepted that e-commerce could bring about income, but one major problem was the need for technical skills and the cost involved in starting online. Participants had identified the areas where skills were most needed as digital marketing, social media management, and customer service. This shows a clear interest among participants in training programs. Apart from this, the respondents reported the need for financial support and reliable internet connectivity to encourage e-commerce adoption in the area. The readiness of coastal communities to develop economically through e-commerce. This study concludes that while many people show an interest and willingness to participate in e-commerce, many factors inhibit such participation-from digital illiteracy through skill deficits to infrastructure inadequacies. Findings also make it clear that interventions such as digital skills training, financial assistance, and infrastructural improvements are necessary for the coastal community in Negombo to enjoy the full benefits of e-commerce. According to the research, closing the digital divide, developing skills, and improving infrastructure will prove to be worthwhile in terms of fostering sustainable economic opportunities in inclusive development efforts.

Keywords: e-commerce; digital literacy; skill development; employment opportunities; coastal communities

KAP of Artificial Intelligence among the Private Sector HR Professionals in Colombo, Sri Lanka

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Abstract

Artificial intelligence (AI) is reshaping the global workforce. However, there is a gap in understanding how human resource (HR) professionals in Sri Lanka utilize these technologies, particularly regarding their usability and associated risks. This research addresses the uncertainty of AI adoption in human resource management (HRM) within the Colombo district. The research objectives were to examine the knowledge, attitudes, and practices (KAP) of AI among private sector HR professionals based in Colombo and assess how knowledge and attitudes influence the practical application of AI in HRM. A quantitative, correlational, cross-sectional design was used to assess the levels of KAP regarding AI among HR professionals, and data were collected via a structured self-administered questionnaire. The validity and reliability of the questionnaire were examined with exploratory factor analysis and Cronbach's alpha coefficients. The scales demonstrated internal consistency for Attitude (α=0.82) and Knowledge (α=0.73). The Practice scale showed lower reliability (α=0.61). Using convenience sampling, 108 HR professionals participated in this study via LinkedIn, and descriptive statistics summarized the demographic variables. The Shapiro-Wilk test indicated non-normality of the KAP scale. The positive correlation between attitude and practice (p=0.395, p<0.01) indicates that positive attitudes toward AI are associated with higher levels of practice, and a moderate negative correlation was found between knowledge and practice (p=-0.503, p<0.001), suggesting that higher knowledge of AI may not necessarily translate into its application. One-way ANOVA revealed significant differences in AI-related knowledge based on organizational size, while no significant differences were found for other demographic variables. Quantile regression was employed to model practice scores, as violations of normality and homoscedasticity assumptions were present. Results confirmed that attitude was a significant positive predictor, and knowledge was a significant negative predictor of AI-related practice.

Keywords: artificial intelligence; human resources; knowledge; attitude; practice

Technological Transformation of Real Estate and Valuation in Sri Lanka: Global Lessons, Local Strategies

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Abstract

The real estate and valuation industry is undergoing a paradigm shift driven by accelerating digital transformation. Innovations such as automated valuation models, artificial intelligence, big data analytics, blockchain, and geospatial technologies are redefining property assessment, management, and transaction processes worldwide. While developed markets have rapidly embraced these tools, Sri Lanka faces the dual challenge of leveraging their benefits while addressing regulatory, infrastructural, and professional readiness gaps. This study investigates how technological disruption is reshaping valuation practices globally and distils lessons relevant to Sri Lanka's profession. The core research problem centers on identifying pathways for the country to transform its largely traditional, manually driven valuation systems in line with international best practices without compromising data integrity, professional judgement, or regulatory compliance. A systematic literature review was undertaken, drawing on peer-reviewed studies, industry reports, and case examples from both advanced and emerging markets. Findings highlight gaps in regulatory frameworks, digital literacy, and data standards alongside opportunities to enhance credibility, efficiency, and market confidence through strategic adoption. Furthermore, a notable lack of empirical studies and research in this subject area is identified. While Sri Lanka has initiated steps such as partial digitization of land registries and growing PropTech awareness, critical structural, institutional, and skill-based challenges persist. The paper proposes a strategic roadmap tailored to Sri Lanka's context, emphasizing hybrid valuation models, regulatory modernization, targeted digital skills development for stakeholders, and regional collaboration. Further research and empirical studies should be encouraged in this area to comprehensively explore the challenges and opportunities associated with digital transformation and to identify the most effective strategies for modernizing the industry with digital transformation. These measures aim to position Sri Lanka's valuation industry as globally competitive, technologically adept, and capable of supporting sustainable economic growth in the digital era.

Keywords: real estate; valuation; PropTech; automated valuation model

Cultural Continuity in Watercolour Education: The Legacy of Aesthetic Philosophy and Technology in Contemporary Chinese and Japanese Art

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Abstract

The pedagogical integration of traditional aesthetic philosophies into contemporary watercolour education remains underexplored, particularly regarding how digital and technological tools mediate this process in Chinese and Japanese art education. This study addresses this gap by examining how aesthetic principles-specifically qi and wabi-sabi-continue to inform artistic practice within technologically enriched classrooms. Using a mixed-methods design, surveys and interviews were conducted with 120 educators and 250 students across major art institutions in China and Japan. Results show that 68% of Chinese educators and 72% of Japanese educators intentionally incorporate traditional principles in combination with digital watercolour applications and online learning platforms. Chi-square analysis ($p<0.05$) revealed that this integration enhances student engagement and creativity, while a t-test comparison ($p<0.01$) showed higher satisfaction among students exposed to digitally supported aesthetic instruction. Qualitative data revealed that Chinese students connected qi to a sense of flow in both digital and physical brushwork, whereas Japanese students related wabi-sabi to the acceptance of imperfection in traditional and digital media. The study highlights how technological mediation sustains and revitalizes traditional aesthetics, creating a balanced framework that fosters creativity, cultural continuity, and pedagogical innovation without displacing heritage-based values.

Keywords: watercolour pedagogy; traditional aesthetics; qi; wabi-sabi; art education; technology integration

An In-depth Examination of E-learning Integration, Operational Challenges, and Strategic Opportunities for Sustainable Development in Sri Lankan Higher Education Institutions

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Abstract

Sri Lanka's higher education system still faces many challenges before e-learning can become a standard way to learn. Currently, universities use learning management systems, video conferencing tools like Zoom, and personal devices such as smartphones and laptops. However, access to the proper infrastructure still seems uneven. This can be seen particularly in rural areas. This issue eventually leads to unstable internet connections and frequent buffering, limited access to quality devices, and also frequent power outages that happen all around the country. Relying on mobile data and hotspots worsens connection issues, impacting the quality and continuity of online instruction. This study examines the challenges and strategic opportunities for sustainable e-learning integration in Sri Lankan higher education through a qualitative review of literature and institutional practices. User adaptation also poses a significant challenge, even aside from technical issues. Many students feel stressed and mentally strained due to limited peer interaction and practical learning. Medical schools and urban universities are starting to embrace online platforms more, but the industry as a whole is still not prepared or equipped for e-learning. Interestingly, some of the students wish to continue learning online. Although a portion of students showed interest in continuing online education post-pandemic, a considerable number remained resistant, highlighting mixed attitudes toward e-learning adoption. The digital divide affects students from low-income families even more. These students struggle because internet access is costly, and schools do not offer enough support for paid digital resources. Academic staff have also faced challenges related to training, platform usability, and a lack of systemic assistance. However, models such as UTAUT-3 indicate that the expectations of performance and effort significantly influence adoption rates. Findings reveal emerging opportunities to strengthen infrastructure, enhance digital literacy, and implement supportive policies for inclusive, resilient, and sustainable e-learning within higher education institutions.

Keywords: e-learning; higher education; Sri Lanka; educational policy

Assessing Higher-order Cognitive Skills Among IT Undergraduates in Sri Lanka

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Abstract

In today's fast-evolving digital landscape, cultivating higher-order cognitive skills (HOCS), namely analytical reasoning, adaptive problem solving (APS), and critical thinking are essential for IT graduates. This study investigates the development of HOCS among IT undergraduates in Sri Lanka, focusing on the influence of gender, Advanced Level subject stream, and university type on three major identified cognitive skill levels. Employing a quantitative methodology, data were gathered from around 80 IT undergraduates in both state and non-state universities to evaluate their cognitive proficiency levels with respect to different IT degree programs. The study is anchored in Bloom's revised taxonomy and constructivist learning theories, offering a strong foundation for examining how pedagogical methods and learning environments support the development of HOCS. It investigates whether significant differences in cognitive skill levels can be observed across gender, Advanced Level subject streams, and university types. To assess these variations, statistical techniques such as ANOVA and t-tests were applied. The findings reveal a substantial disparity between the expected and actual levels of cognitive performance among students, particularly in analytical reasoning and APS. Moreover, the study highlights differences influenced by students' year of study, gender, and socio-cultural background. These outcomes underscore the importance of adopting tailored teaching strategies to close cognitive gaps and strengthen critical thinking within IT education. The research provides valuable implications for curriculum development and instructional practices in Sri Lankan higher education by presenting a model for managing HOCS through curriculum enhancement, evidence-based interventions, and institutional policy measures. Its contributions are especially relevant to education administrators, curriculum developers, and policymakers seeking to design more focused and impactful learning experiences. Ultimately, the study aspires to reduce the cognitive divide in IT education and better equip students to meet the challenges of the knowledge-driven economy.

Keywords: higher order cognitive skills; analytical reasoning; adaptive problem solving; critical thinking

The Impact of AI Usage on Digital Leadership: The Moderating Role of Digital Maturity in Sri Lankan IT Companies

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Abstract

The rise of artificial intelligence (AI) has altered the dynamics of leadership in the digital age, transforming decision-making, communication, and innovation processes within organizations. Therefore, people in leadership positions, specifically in IT companies, face difficulties in managing the people as the work demands more time. This study investigates the impact of AI usage on digital leadership, with a special emphasis on the moderating role of digital maturity. Based on contingency theory, the study argues that AI enables leaders to enhance strategic agility, cooperation, and data-driven decision-making, ultimately leading to more successful digital leadership. However, the extent to which AI enhances leadership effectiveness depends on the organization's digital maturity. Digital maturity measures an organization's readiness, infrastructure, and cultural alignment to implement and sustain digital transformation activities. Data were collected using convenience sampling from 402 IT employees in Sri Lanka and analyzed through Smart PLS 4.0. AI integration is aided by strong systems, talented workers, and innovation-oriented cultures in highly developed organizations, enhancing the benefits of digital leadership on performance and flexibility. In contrast, firms with low digital maturity face problems such as technological gaps, employee opposition, and limited resources, which may undermine or even nullify the benefits of AI-enabled leadership. Digital maturity was found to strengthen the impact of AI on digital leadership. This study contributes to the expanding body of knowledge about leadership in the digital economy by emphasizing the contextual value of digital maturity when harnessing AI for leadership effectiveness. In addition to that, it adds value to literature with a new concept of digital maturity along with AI integration in the Sri Lankan context. The findings highlight the importance of firms investing in digital capabilities and cultural preparation before completely integrating AI into leadership practices. By doing so, businesses can ensure that AI adoption leads to significant leadership results, supporting creativity, resilience, and competitive advantage in an increasingly digitalized environment.

Keywords: artificial intelligence; digital maturity; digital leadership. it companies; Sri Lanka

The Impact of Technology-Enhanced Learning Environments on Student Engagement: The Moderating Role of Self-regulated Learning among Undergraduates in Sri Lankan State Universities

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Abstract

Technology-enhanced learning environments (TELEs) have become a crucial component of higher education, offering interactive and flexible learning options that enhance student engagement. However, the extent to which students actively participate in such contexts is determined by their particular learning qualities. This study examines the impact of TELE on student engagement, with a specific emphasis on the moderating role of self-regulated learning (SRL). Drawing on self-regulated learning theory, the study contends that TELE offers opportunities for engagement, but their effectiveness depends on students' ability to organize, monitor, and manage their own learning. Data were acquired from a convenience sample of 407 undergraduate students enrolled in Sri Lankan state universities. A standardized questionnaire was utilized to collect information from students about their perceptions of TELE, involvement levels, and SRL behaviors. SPSS was used for statistical analysis, and the hypothesized associations were tested using moderation analysis. The findings show that TELE has a favorable impact on student involvement across behavioral, cognitive, and emotional dimensions. Importantly, SRL was found to significantly moderate this relationship: students with greater levels of SRL showed stronger interest when exposed to TELE, whereas those with lower SRL showed reduced engagement despite the presence of digital learning possibilities. The findings add to the technology in education and engagement literature by emphasizing SRL as a fundamental boundary condition in the TELE-engagement nexus. To maximize engagement and learning outcomes, the study recommends that colleges invest not only in digital learning platforms but also in students' self-regulated learning skills. This study adds novelty to the existing literature by these three variables.

Keywords: technology-enhanced learning environment; student engagement; self-regulated learning

Technical Sessions

27th November
Venue – Faculty of Technology, University of Sri Jayewardenepura

Oral Presentation Sessions

	Track	Venue	Time
Morning	GGG/BCI - Geo Resources, Geo Environment and Geotechnics/Building Construction and Infrastructure Technology	LGF 07	9.00 am -12.40 pm
	MEPT - Materials Engineering and Process Technology	Session 01 GF 06 Session 02 GF 07	9.00 am -12.20 pm 9.00 am -12.20 pm
	ATS - Agricultural Technologies for Sustainability	Session 01 GF 04 Session 02 GF 05	9.00 am -11.00 am 9.00 am -11.00 am
	AID - Artificial Intelligence and Data Science	Session 01 GF 01 Session 02 GF 02 Session 03 GF 03	9.00 am - 11.00 am 9.00 am - 11.00 am 9.00 am - 10.40 am
	EES - Energy, Environment and Sustainability	LGF 06	9.00 am -11.40 am
	TEM / SFT - Technology Education and Management/ Science for Technology	LGF 08	9.00 am- 12.40 pm
	FNP - Food Security, Nutrition, and Processing Technology	Session 01 GF 08 Session 02 GF 09	9.00 am- 12.00 pm 9.00 am- 11.40 am
	AISSSI - Applied Information Systems, Strategy, and Societal Impacts	LGF 09	9.00 am- 12.00 pm
Evening	AISSSI - Applied Information Systems, Strategy, and Societal Impacts	FF 05	1.00 pm- 2.20 pm
	MRA - Mechatronics, Robotics, and Automation	SF 02	1.00 pm-3.20 pm
	IE/AE - Industrial Electronics/Automotive Engineering	LGF 01	1.00 pm- 2.20 pm
	BBI - Biotechnology, Bioengineering, and Industrial Bioprocessing	Session 01 FF 07 Session 02 FF 08	1.00 pm- 3.20 pm 1.00 pm- 3.20 pm
	CM - Communication and Networking	FF 01	1.00 pm- 2.20 pm

Technical Sessions

27th November
Venue – Faculty of Technology, University of Sri Jayewardenepura

Poster Presentation Sessions

	Tracks	Session	Venue	Time
Morning	Artificial Intelligence and Data Science	Session 1	SF1	9.00 a.m.- 12.00 p.m.
	Food Security, Nutrition, and Processing Technology			
	Applied Information Systems, Strategy, and Societal Impacts/ Interactive Media Technology	Session 2	FF06	9.00 a.m. – 12.00 p.m.
	Biotechnology, Bioengineering, and Industrial Bioprocessing			
Evening	Agricultural Technologies for Sustainability	Session 3	SF1	12.45 p.m. – 3.45 p.m.
	Energy, Environment, and Sustainability			
	Materials Engineering and Process Technology	Session 4	FF06	12.45 p.m. – 3.45 p.m.
	Mechatronics, Robotics, and Automation			
	Science for Technology			
	Technology Education and Management			

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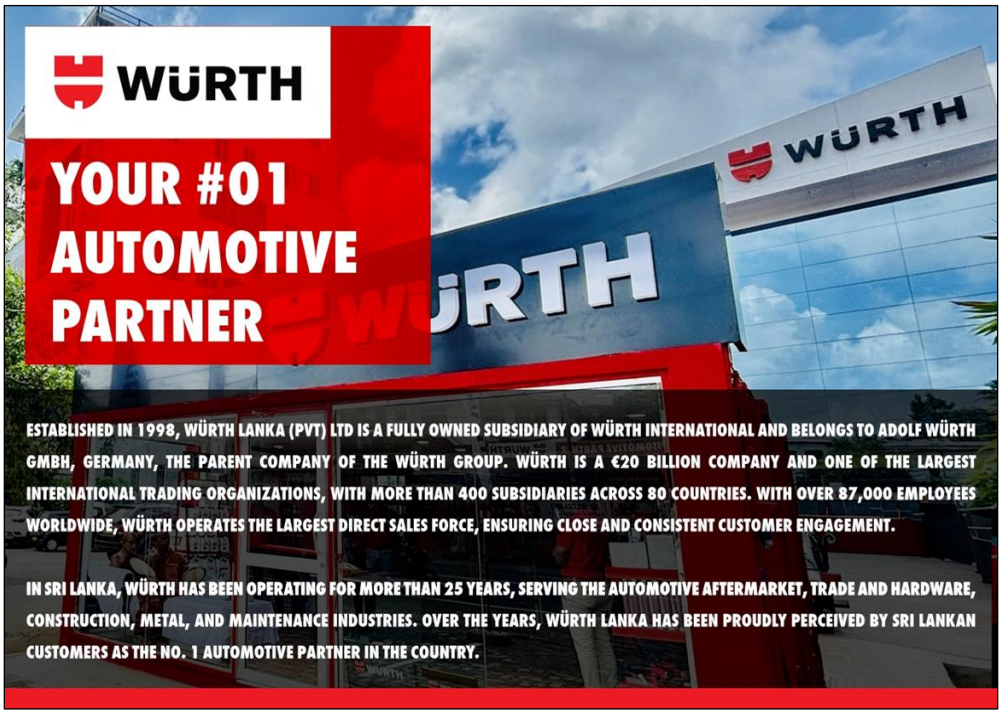
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