ICET 2025
ISSN 3084-8628

INTERNATIONAL CONFERENCE ON EMERGING TECHNOLOGIES

"TECHNOLOGY FOR SUSTAINABLE FUTURE"

BOOK OF ABSTRACTS

2ND APRIL 2025

FACULTY OF TECHNOLOGY
SABARAGAMUWA UNIVERSITY
OF SRI LANKA, BELIHULOYA

ICET 2025

International Conference on Emerging Technologies

02ND APRIL 2025

FACULTY OF TECHNOLOGY

SABARAGAMUWA UNIVERSITY OF SRI LANKA

ICET 2025

International Conference on Emerging Technologies
Faculty of Technology, Sabaragamuwa University of Sri Lanka

Symposium https://www.sab.ac.lk/tech/icet

Organized by the Faculty of Technology of the Sabaragamuwa University of Sri Lanka, 2nd April, 2025

ISSN: 3084-8628

ICET 2025 serves as a global platform for researchers, academics, and professionals to present their latest findings, exchange ideas, and demonstrate their potential as contributors to scientific and technological advancement. The conference brings together a diverse scholarly and industrial community, fostering opportunities for academic collaboration, industry partnerships, and international networking. ICET 2025 encourages participants to explore emerging trends on both local and global scales across multiple disciplines, and to share developments in technology, innovation, skills, and knowledge that contribute to sustainable and impactful progress.

Editor-in-Chief: Prof. K.R. Koswattage

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Published by : Sabaragamuwa University of Sri Lanka
Contact : icet@tech.sab.ac.lk

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Message from the Vice Chancellor – Sabaragamuwa University of Sri Lanka

It gives me great pleasure to extend my heartiest congratulations for the International Conference on Emerging Technologies (ICET) 2025, organized by the Faculty of Technology, Sabaragamuwa University of Sri Lanka under the theme of "Technology for a Sustainable Future." This remarkable event is a significant milestone in the university's journey toward academic excellence and impactful research.

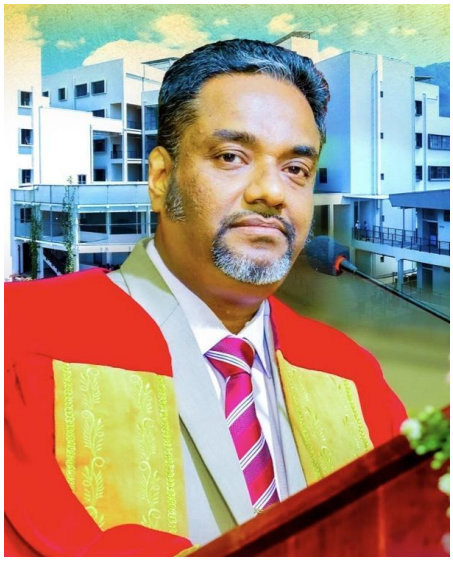
In an era marked by rapid technological advancements and environmental challenges, the role of emerging technologies has never been more critical. Technological innovation has the potential to address pressing global issues such as climate change, resource depletion, and societal inequalities. By fostering a multidisciplinary dialogue through ICET, we are taking a meaningful step towards building a sustainable and inclusive future.

The Faculty of Technology, as a pioneering academic body, continues to demonstrate its dedication to research and development that meets international standards. ICET provides a valuable platform for researchers, innovators, and industry experts to exchange ideas and showcase their contributions towards a technologically advanced yet environmentally conscious world.

I extend my sincere gratitude and congratulations to the organizing committee, keynote speakers, paper presenters, and all participants for their invaluable contributions to this conference. May ICET 2025 be a resounding success, paving the way for future advancements in emerging technologies.

Professor M. Sunil Shantha
Vice-Chancellor
Sabaragamuwa University of Sri Lanka

Message from the Dean - Faculty of Technology



It is with immense pride and heartfelt joy that I extend my warmest wishes for the success of the *1st International Conference on Emerging Technologies (ICET 2025)*, organized by the Faculty of Technology, Sabaragamuwa University of Sri Lanka.

This inaugural conference marks a significant milestone for our faculty, and I am truly delighted to witness it come to life with such energy, purpose, and excellence. I would like to express my sincere appreciation to the Organizing Committee for their tireless dedication and outstanding efforts. You have done a truly wonderful job, and this accomplishment is a reflection of your hard work and unwavering commitment.

As the first of its kind, ICET 2025 has already set a high standard. I am confident that this conference will continue in the years ahead, growing stronger and more impactful with each edition. I firmly believe that this initiative will play a key role in fostering a vibrant research culture within our university and beyond.

What fills me with particular happiness is the enthusiasm shown by our undergraduate students, many of whom have stepped forward with a passion for research and innovation that goes far beyond our expectations. Their spirit is a reminder of the bright future ahead and the transformative potential of empowering young minds.

It is clear to me that the Faculty of Technology is moving decisively toward becoming the leading force in research at Sabaragamuwa University. We are on the right path—and this conference is a bold step forward. Once again, my heartfelt thanks to everyone involved. May ICET 2025 be a resounding success and a launchpad for lasting collaboration, innovation, and academic excellence.

With warm regards,

Prof. K.R. Koswattage
Dean
Faculty of Technology
Sabaragamuwa University of Sri Lanka

Message from the Conference Chair (ICET 2025)

On behalf of the organizing committee, I am proud to welcome all participants to the *International Conference on Emerging Technologies (ICET 2025),* themed "Technology for a Sustainable Future." It is with great pleasure that we present this conference as a platform for knowledge exchange and innovative discussions. As technology rapidly evolves, we must harness its potential to mitigate issues such as environmental degradation, resource depletion, and social inequities. The impact of emerging technologies on building a sustainable future cannot be overstated. Therefore, ICET 2025 aims to foster dialogue on how these advancements can contribute to a better tomorrow.

The conference features researchers and experts presenting solutions to some of the most pressing challenges in technology and sustainability. I am confident that ICET 2025 will provide a valuable platform for collaboration, inspiring new ideas and approaches that will contribute to scientific advancements.

I am delighted to share that ICET 2025 will host over 100 researchers from diverse disciplines, showcasing research in areas ranging from basic scientific studies to innovative technological applications. The conference is structured to include sessions such as advances in emerging sciences, bioenergy and biofuel generation technology, applied biotechnology and microbiology, mechanical engineering technology, and electrical and electronic engineering technology, offering attendees a comprehensive learning experience.

I would like to extend my heartfelt gratitude to all presenters for their contributions and to the academic and administrative staff of the university for their dedication and support in making this conference a success.

I wish all participants a productive and enriching experience at ICET 2025.

Dr. Kasundi Gunasena
Conference Chair
International Conference on Emerging Technologies (ICET 2025)

Message from the Conference Secretary - (ICET 2025)

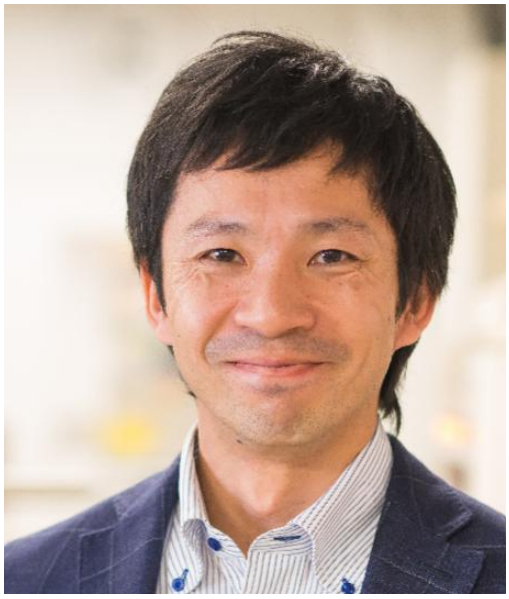
It is my great pleasure to extend a warm welcome to all participants of the International Conference on Emerging Technologies (ICET 2025), hosted by the Faculty of Technology, Sabaragamuwa University of Sri Lanka. In an era where technology drives global progress, ICET 2025 stands as a vital platform for knowledge sharing and collaboration to address global challenges through innovation. The conference, themed "Technology for a Sustainable Future," brings together researchers, academics, and industry experts to exchange ideas and showcase innovative solutions.

ICET 2025 features several key sessions that cover wide range of disciplines, including Emerging Sciences, Bioenergy and Biofuel Generation Technology, Applied Biotechnology and Microbiology, Mechanical Engineering Technology, and Electrical and Electronic Engineering Technology. This multidisciplinary approach is designed to foster collaboration and inspire creative solutions that support sustainability and technological advancement.

I would like to express my sincere gratitude to the organizing committee, keynote speakers, paper presenters, and participants for their dedication and contributions. Special thanks also go to the university's academic and administrative staff for their tireless efforts in making this event a reality. I wish all attendees a successful and inspiring conference experience. May ICET 2025 ignite innovative ideas that shape a sustainable and technologically advanced future.

Mr. E.R.J.M.D.D.P. Wijesekara
Conference Secretary
International Conference on Emerging Technologies (ICET 2025)

Message from the Keynote Speaker



It is a great honor and privilege for me to join the *International Conference on Emerging Technologies (ICET) 2025* at the Faculty of Technology, Sabaragamuwa University of Sri Lanka.

This is my first visit to Sri Lanka, and I am truly grateful for the warm welcome extended by the university and the organizing committee. I am particularly delighted to reunite with Prof. Kaveenga Rasika Koswattage, Dean of the Faculty, with whom I had the pleasure of collaborating at the UVSOR Synchrotron Facility in Japan. His contributions to the development of our experimental stations were both valuable and inspiring, and it brings me great joy to see him leading such a dynamic academic initiative.

The theme of this year's conference, *"Technology for a Sustainable Future,"* resonates deeply with the global scientific community. As we face complex environmental and societal challenges, it is increasingly important to foster international dialogue and multidisciplinary collaboration. ICET provides a timely and vital platform for such engagement, bringing together researchers, students, and professionals to share ideas and innovations that will shape our future.

I look forward to engaging in fruitful discussions, exploring new perspectives, and witnessing the groundbreaking research being carried out here. I sincerely wish ICET 2025 every success and hope it becomes a cornerstone event that continues to promote global collaboration and scientific excellence in the years to come.

With warm regards,

Prof. Satoshi Kera
Institute for Molecular Science, Japan
Director, UVSOR Synchrotron Facility

Spotlight on Excellence

Halogen ion migration in lead halide perovskite solar cells

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Abstract

Renewable energy sources to replace conventional fossil fuels are critical for establishing a sustainable society. Among the renewable energy sources, solar cells play a crucial role and are expected to see further expansion in the near future. In addition to traditional silicon-based devices, there is a growing demand for developing next-generation solar cells suitable for diverse applications. Lead halide perovskites (LHPs) have emerged as promising photoactive material. LHPs have exceptional properties, such as high light absorption, efficient charge transport, compatibility with multiple fabrication methods, and compositional tunability. This presentation explores the fundamental principles behind these outstanding characteristics of LHPs and the challenges that must be addressed for real-world implementation. We also discuss our recent findings on halogen ion migration in LHP solar cells. The migration of halogen ions is a crucial factor that affects device longevity. To mitigate this issue, we propose adopting a perovskite double-layer configuration and optimizing the deposition conditions of the top electrode. These strategies help suppress halide ion migration and enhance the overall stability of LHP solar cells.

Keywords: *Solar cells, Lead halide perovskites, Ion migration, Thin film interfaces*

Sustainable Waste Valorisation: Biochar Production from Municipal Solid Waste

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Abstract

Municipal solid waste (MSW) has emerged as one of the most pressing global challenges of the decade, driven by population growth, urbanisation, and economic development. The biodegradable fraction of MSW can be decomposed through microbial activities or utilized for biochar production via pyrolysis. Advanced biomass valorisation methods, especially those focused on biochar derived from the torrefaction of biodegradable waste, present viable strategies for managing leachate generation in pathways involving microbial activities. Torrefaction, a form of slow pyrolysis, is designed to maximise biochar yield. In dry torrefaction, organic material is heated in the absence of oxygen (or with limited oxygen) at slow heating rates (0.2–12 °C/min), moderate residence times, and relatively low temperatures (<350 °C). Slow pyrolysis enhances carbon yield by 40–65%, depending on the applied temperature. The pyrolysis process requires heat, which can be supplied by the heat generated from exothermic reactions or through direct/indirect heat transfer between heat carriers and solid materials. Additionally, syngas produced during pyrolysis can be utilized to partially meet the heat requirements for biochar production. The objective of the current study is to analyse the biochar conversion process in a semi-autothermal reactor using Computational Fluid Dynamics (CFD). The biodegradable components of MSW are classified as a combination of hemicellulose, cellulose, and lignin to enable the implementation of chemical kinetics in CFD simulations. The simulations reveal biochar yields of 20 wt%, 6.5 wt%, and 45.7 wt% for hemicellulose, cellulose, and lignin, respectively, with lignin exhibiting the highest yield. The composition of MSW varies depending on its source. Additionally, the heat produced by the system can be recovered to dry bio-waste, aiding in the removal of excess moisture when necessary.

Keywords: *Biochar, CFD, MSW, Pyrolysis, Valorisation*

Investigation of Ionic Conductivities in Natural Rubber-Based Solid Polymer Electrolytes with different Salts for suitability in Energy Storage Applications

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Abstract

The growing demand for efficient, sustainable, non-toxic and eco-friendly materials in energy storage devices has spurred interest in solid polymer electrolytes (SPEs) for their potential in applications such as batteries and super capacitors due to environmental impact of fossil fuels. This study presents a comparative analysis of natural rubber-based solid polymer electrolytes (NR-SPEs) doped with various salts, focusing on their ionic conductivity and suitability for energy storage devices. Natural rubber, known for its excellent mechanical properties, is explored as a renewable polymer matrix with the enhancement with 49% polymethyl methacrylate grafting. A range of salts—such as ammonium trifluoromethanesulfonate ($NH_4(CF_3SO_3)$ - NH_4TF), zinc trifluoromethanesulfonate ($Zn(CF_3SO_3)_2$ - ZnTF) and magnesium trifluoromethanesulfonate ($Mg(CF_3SO_3)_2$ - MgTF) are incorporated into the NR matrix by traditional solvent casting technique to investigate their effects on ionic conductivity. The synthesized NR-SPEs are characterized using techniques including linear sweep voltammetry, electrochemical impedance spectroscopy,DC polarization and cyclic voltammetry tests. The results demonstrate that conductivity values of NR: NH4TF, NR:ZnTF and NR:MgTF were 3.82 × 10^{-4} S cm^{-1}, 0.6×10^{-3} S $cm^{-1}$and 3.3 x 10^{-3} S cm^{-1}respectively. The findings of this study highlight the potential of NR-SPEs for use in energy storage devices, offering a path toward more efficient and environmentally friendly electrolyte materials. The enhanced ionic conductivity and the inherent advantages of using natural rubber make these materials a promising candidate for future energy storage technologies.

Keywords: *ammonium trifluoromethanesulfonate, zinc trifluoromethanesulfonate, magnesium trifluoromethanesulfonate, conductivity, Electrochemical Impedance Spectroscopy.*

Experimental Study on Thermal Conductivity, Thermal Diffusivity, and Viscosity of MgO:Graphite Nanocomposite – Engine Oil Nanofluid

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Abstract

The integration of nanocomposites into conventional lubricants has emerged as a promising approach to enhance thermal and rheological properties, permitting improved heat dissipation and energy efficiency in engine applications. This study demonstrates MgO:Graphite nanocomposite based nanofluids synthesized by a two-step direct mixing method and dispersed in Mobil 10W30 engine oil at three different weight ratios (0.01, 0.05. 0.1) to evaluate their thermos-physical properties such as thermal conductivity, thermal diffusivity, and dynamic viscosity. The nanocomposite was synthesized via an optimized process and characterized using different characterization methods such as SEM, FTIR, and XRD to confirm its morphology, chemical bonding, and crystallinity. The FLUCON LAMBDA thermal conductivity meter was used to measure the thermal conductivity and thermal diffusivity by ASTM D7896-19 standard at temperature range of 30-100℃ with step size 10, while viscosity variations were analyzed using the SVM3000 viscosity meter at temperature range 20-100℃ with step size 20. The incorporation of the MgO:Graphite nanocomposite significantly enhanced the thermal conductivity (8% at 60℃ from 0.1wt.%) of the base oil, without a notable increase in thermal diffusivity, indicating improved heat transfer efficiency. The enhancement is attributed to the synergistic effect of highly conductive Graphite and thermally stable MgO, which facilitate efficient phonon and electron transport in the nanofluid. However, a proportional increase in viscosity was observed with higher nanocomposite loading, which may influence the fluid dynamics in practical applications. The observations prove the potential of MgO:Graphite nanocomposite-based nanofluids as high-performance lubricants with superior thermal properties, making them viable candidates for advanced thermal management in automotive and industrial applications. The future research works will focus on further development of the nanofluids, by optimizing dispersion stability, controlling viscosity, and assessing the tribological performance for real-world engine systems.

Keywords: *MgO:Graphite nanocomposite, Nanofluid, Engine oil, Thermo-physical properties*

Microplastic Conundrum: Sources, Fate and Transportation, Quantification, Characterization, Impacts and Remediation

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Abstract

Non-degradable synthetic plastics have led to a global environmental crisis due to their excessive usage. This plastic usage has influenced the generation and accumulation of alarming amounts of microplastics in complex environmental matrixes such as terrestrial and aquatic spheres. Microplastics impact the soil's biogeochemical properties and microbiological functions, thereby influencing human health. Seawater and freshwater contamination with microplastic is posing serious risks to such ecosystems. The ingestion of microplastics by aquatic organisms such as plankton, fish, shellfish, and other marine species can happen directly or indirectly. Further, a wide range of sea salt products from different parts of the world are contaminated with microplastics, and finally affect them to human health. Therefore, the removal of microplastics from these environments is critically important. To tackle the dilemma, researchers across the globe have been collectively conducting investigations in developing remediation methods and minimizing microplastic contamination. Nanomaterial-based (magnetite, graphene oxide, carbon nanotubes, natural chitosan) technological applications are showing promising performance in removing microplastics in water. These novel materials can be used as material with higher microplastic capturing efficiency and filtering performance. Bioplastic has also been found as an alternative to replace synthetic plastics to avoid the discharge of microplastic into the environment. There are avenues to modify bioplastic structure using environmentally friendly nano materials. The application of artificial intelligence-based tools is also shown to have promising opportunities to optimize the identification, quantification, and remediation of microplastics and therefore lightning way forward.

Keywords: *Emergining contaminants, Environmental remediation, Green nanotechnology, Nanoplastics, Water pollution*

Modelling Neglected and Underutilised Crops: A Pathway to Food Security and Sustainability

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Abstract

Current agricultural production depends on a limited number of species grown as monocultures that are highly vulnerable to climate change, presenting a threat to the sustainability of agri-food systems. However, there are many neglected and underutilised crop (NUC) species which have the potential to cater to the challenges of climate change through resilience to adverse climate conditions. Since many of these crops remain unknown to the public and wider agricultural stakeholders, they are not included in the local and national agricultural development programmes. One of the major barriers to the inclusion of minor crops in the developmental programmes is the lack of knowledge about their suitability at different geographic scales. Increasing global demand for food has transformed production systems around the world. The digitalisation of agriculture, which is one of the major drivers of technological innovation, has played an important role in improving the productivity of agro-ecosystems. Crop models that simulate plant growth, development and yield as functions of environment, management and defined genetic characteristics, can be successfully used to assess the suitability of NUCs. There are several success stories around the world where NUCs were studied in detail using crop modelling approaches. For example, Proso millet has been identified as an excellent candidate for low-input farming systems under climate change in Sri Lanka. In order to motivate further research into the use of state-of-the-art techniques in modelling for less known crops, an ideotyping technique was developed and applied in simulating hemp production in data-scarce tropical environments like Malaysia and Sri Lanka. The integration of neglected and underutilised crops and crop modelling approach offers a powerful pathway towards building more resilient, diverse, and sustainable food systems.

Keywords: *agri-environmental modelling, climate change, climate smart agriculture, future crops.*

Advances in Emerging Sciences

Innovative Self-Cleaning Superhydrophobic Coating for Printed Paper: Protecting Ink Integrity, Facilitating Printability and Writability

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Abstract

The growing demand for sustainable alternatives to plastic has driven the development of superhydrophobic papers, particularly for packaging, printing, and writing applications, due to their enhanced water resistance and improved durability. This study introduces a simple yet effective method for creating superhydrophobic coatings on printed paper that preserves ink without causing any damage, allowing the paper to remain suitable for printing and writing even after coating. The coating was prepared using tetraethyl orthosilicate (TEOS) and 1H, 1H, 2H, 2H-perfluorooctyltriethoxysilane (PFOTS) via a sol-gel process and was applied using a coating sponge. This led to a multi-layered, porous nano-micro structure, having a random arrangement of modified SiO_2 nanoparticles. The resulting surface achieved an impressive water contact angle of 165°±2°, indicating excellent hydrophobicity. The tensile strength of the paper increased by 4 MPa after superhydrophobic treatment and the hydrophobic properties were stable across a wide pH range from 1 to 11. Moreover, the superhydrophobic surface retained its water-repellent properties after 110 abrasion cycles on sandpaper and exhibited efficient self-cleaning abilities against mud, sauces, and beverages. In contrast to traditional methods of preparing superhydrophobic papers, this novel approach allowed the coating to be applied directly onto the printed areas without damaging the printed ink. Additionally, it ensured that the paper retains printability and writability after the superhydrophobic treatment. Hence, this study provides an innovative, cost-effective method for creating superhydrophobic coatings on printed paper, enhancing durability and water resistance while preserving printability and writability, offering a sustainable solution for packaging and writing applications.

Keywords: *1H, 1H, 2H, 2H-perfluorooctyltriethoxysilane, Self-cleaning, Superhydrophobic paper, Tetraethyl Orthosilicate*

Impact of Reaction Time on the Synthesis of Graphene Oxide: Structural and Optical Analysis for Enhanced Sensor Performance

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Abstract

Graphene oxide (GO) is a favorable nanomaterial with adjustable material properties, making it widely applicable in various fields, including electronics, energy storage, and biomedical applications. The synthesis conditions notably influence the properties of GO, with reaction time playing important role in determining its oxidation level, and structural integrity. In this study, GO was synthesized using a modified Hummers' method at different reaction durations (6, 12, 18, 24 and 30) hours to evaluate its structural, and optical characteristics. The synthesized GO samples were characterized using multiple techniques. Scanning Electron Microscopy (SEM) was used to analyze morphological variations, while Fourier-Transform Infrared Spectroscopy (FTIR) confirmed functional group modifications associated with oxidation. X-ray Diffraction (XRD) provided information into crystallographic changes, and Ultraviolet-Visible Spectroscopy (UV-Vis) was employed to study optical properties. The results revealed that extended reaction times (24 and 30) hours leads to a decrease in oxygen-containing functional groups, as confirmed by FTIR spectra, indicating a reduction in oxidation levels. XRD analysis showed a decrease in interlayer spacing with longer reaction durations, further supporting the reduction in oxidation. UV-Vis spectral analysis exhibited absorption shifts corresponding to changes in oxidation levels. SEM images demonstrated significant morphological differences, where shorter reaction times resulted in more exfoliated and wrinkled GO sheets, while longer durations led to smoother and more aggregated structures. GO synthesized at moderate reaction times exhibited a balance between oxidation and structural stability, providing active sites for covalent binding, enzymatic immobilization, and enhanced enzyme stability, which is key factors for biosensor applications. These findings highlight the crucial role of reaction duration in functionalizing the physicochemical properties of GO, enhancing its optimization for specific applications such as biosensors, drug delivery, and advanced nanocomposites. Understanding the relationship between synthesis parameters and GO properties direct the way for optimizing its functionality for targeted nanotechnology applications.

Keywords: *Biosensor Applications, Graphene Oxide, Oxidation Level, Reaction Time, Structural Properties*

Eco-Friendly Green Reduction of Graphene Oxide: Morphological and Chemical Insights for Conductive Applications in Printing Toners

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Abstract

Reduced graphene oxide (rGO) has gained significant attention due to its versatile properties including tunable electrical conductivity, higher mechanical strength, and compatibility with composite formulations. This study investigates the potential of utilizing rGO as a conductive agent in printing toner formulations. The rGO was synthesized via a modified Hummers' method followed by the reduction using green reducing agents specifically, ascorbic acid and Guava leaf extract, known for their high content of polyphenols and flavonoids with reduction capabilities. From a series of graphene oxide (GO) samples synthesized by oxidizing raw graphite of Bogala, Sri Lanka by systematically varying the key parameters including acid ratio (H_2SO_4:H_3PO_4), reactant ratio (graphite: $KMnO_4$) and reaction temperature, the best-oxidized samples were reduced at 70 °C. SEM, FTIR, and XRD results of the GO samples confirmed the formation of GO yielding well-exfoliated and wrinkled GO sheets with increased interlayer spacing due to oxygen functionalization indicating successful oxidation. These results suggest that both acid ratios (9:1 and 4:1) with graphite: $KMnO_4$ ratio of 1:3 could be used to obtain highly oxidized GO at lower reaction temperature (40 °C). The FTIR spectra of all rGO samples indicated a notable reduction in oxygen-containing functional groups, implying effective reduction. SEM images revealed that rGO produced using ascorbic acid exhibited a highly wrinkled and porous structure, suggesting a strong reduction while Guava extract produced a smoother and more compact morphology indicating a milder reduction. These structural differences may arise from variations in reduction capabilities, with ascorbic acid acting as a stronger reducer compared to the polyphenols and flavonoids in guava extract. Such differences could influence their potential application in toners where the wrinkled rGO may enhance electrical conductivity but could lead to poor dispersion in toner formulations. In contrast, smoother rGO could offer better dispersion but moderate conductivity. Future research will explore the eligibility of these rGOs as a potential conductive agent in printing toners.

Keywords: *Graphene oxide, Green reducing agents, Hummers' method, Reduced graphene oxide*.

Synthesis of Ascorbic acid/ Zn-Al Layered Double Hydroxide/agar Bio-nanohybrids for Skincare Cosmetics

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Abstract

Ascorbic acid (AA), a water-soluble vitamin and antioxidant, is crucial for various physiological functions. Layered double hydroxides (LDHs), known for their layered structure, are utilized for skin protection and drug delivery in dermatology. In this study, AA/Zn-Al LDH/ agar bionanohybrids were synthesised using coprecipitation & ion exchange methods and AA release behaviour was studied. It was observed that AA/LDH/ agar nanocomposites enhance stability and enable controlled released of AA. AA standard curve was prepared with concentrations ranging from 5.0-25.0 mgL^{-1}. Synthesis of AA/Zn-Al-LDH via Co-precipitation and Ion-exchange and incorporation of agar matrix were investigated. Nanohybrids were characterized with Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), and Thermogravimetric Analysis (TGA). The release of AA was examined by adding 100 mg of LDH to $50cm^3$ of distilled water at room temperature. Aliquots were withdrawn at different time intervals and the concentration of released AA was measured at 265 nm using UV-Visible spectrophotometry. Intercalated AA percentages were 99.74% and 99.61% for Co-precipitation and Ion-exchange methods. Crystallite sizes of AA/Zn-Al-LDH(Coprecipitation) and AA/Zn-Al-LDH(Ion-exchange) were 22.0 A° and 123.6A° and both materials show a significant shift in XRD basal spacing. In AA-LDH, FTIR peaks at $1360cm^{-1}$ and $1630cm^{-1}$ correspond to lactone linkages and carbonyl groups, respectively. These results confirm the successful formation of Nanohybrids. According to TGA, AA/LDH and AA/LDH/agar synthesized by both methods show significant weight loss only after 300°C. This confirms intercalation has improved the thermal stability of AA. After 80 minutes, AA/Zn-Al-LDH(Co-precipitation) and AA/Zn-Al-LDH(Ion-exchange) showed release of 0.68 mgL^{-1} and 12 mgL^{-1} of AA confirming slow and controlled release of AA from AA/Zn-Al-LDH(Co-precipitation). Similarly, AA/Zn-Al-LDH(Co-precipitation)/Agar and AA/Zn-Al-LDH(Ion-exchange)/Agar showed 0.19 $mgL^{-1}$and 3 mgL^{-1} of AA. This confirms enhanced controlled release of AA from agar nanohybrids.The study demonstrates successful intercalation of AA into Zn-Al-LDH using both methods. AA/Zn-Al-LDH/Agar Bio-Nanohybrids exhibit controlled release behavior, making them promising candidates for skincare cosmetics. Using non-toxic compounds further emphasizes their potential effectiveness and safety for skincare applications.

Keywords: *Bio nanohybrids, Nanocomposite, Skincare cosmetics, Zn-Al layered double hydroxide*

Electrospun Polyvinyl Alcohol (PVA)/ Hydrolyzed Collagen (HC)/ Reduced Graphene Oxide (rGO) Blended Antibacterial Nanofibers

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Abstract
Electrospinning is a simple and versatile technique to fabricate fibers in the nano and micrometer scale. Reduced graphene oxide is known for its antibacterial properties while hydrolyzed collagen is a bioactive compound that promotes skin tissue regeneration by stimulating new collagen production. In this study, novel electrospun fiber mats with polyvinyl alcohol (PVA), hydrolyzed collagen (HC) and reduced graphene oxide (rGO) were fabricated under different conditions to determine the optimum solution and process parameters. Accordingly, trials were done by varying the PVA concentration from 6% - 10%, needle gauge from 19G-27G, and the applied voltage from 15-30 kV. Continuous fibers were obtained with the solution containing 10% PVA, 5% HC, and 0.05% rGO, without any visible dripping during electrospinning. Scanning electron microscopy images showed that the fibers were bead-free when electrospun using a rate of 2 ml hr^{-1},a tip to collector distance of 12 cm and an applied voltage of 20 kV. Produced mats had a random fiber arrangement with an average thickness of 0.12±0.03 mm. The fiber diameter ranged from 250-500 nm, mimicking the fibrous components of the extracellular matrix. FTIR analysis confirmed the presence of PVA and HC on fibers. Reduction in the peak intensities was observed with the increase in rGO content in the fibers. Raman analysis confirmed the presence of rGO in the fibers. The average Young's modulus, ultimate tensile strength, and strain at break were 9.87±2.53 MPa, 2.52±0.70 MPa, and 95.04±7.66% respectively. The extensibility of the fibers was due to the incorporation of PVA. Stronger affinity of the fibers with water necessitated improving their mechanical stability in aqueous media through cross-linking. Swelling ratio and degradability of the cross-linked fiber mats will be studied along with their antibacterial performance to investigate their potential in wound healing applications.

Keywords: *Antibacterial, electrospinning, nanofibers, reduced graphene oxide, wound healing*

Enhanced Synthesis of Graphene Quantum Dots from Graphite: Optimizing Hydrothermal Reduction of Graphene Oxide

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Abstract

This study presents a novel and efficient two step synthesis method for graphene quantum dots (GQDs) derived from graphite focusing on optimizing yield and optical properties while maintaining cost-effectiveness. The approach combines top-down hydrothermal and chemical exfoliation techniques, to break down bulk carbon materials. Initially, graphite was oxidized to graphene oxide using the modified Hummers method, followed by hydrothermal treatment with 6 % of Hydrogen peroxide and ethanol to produce GQDs. The quantum confinement effect is a critical factor that influencing the optical and electrical properties of GQDs, was leveraged to enhance their performance. The synthesis conditions, including temperature and reaction time, were systematically optimized. UV- Vis absorbance peaks for the as-prepared GQDs were observed at 230 nm and 250 nm, which shifted to 260 nm and 305 nm under optimized conditions, indicating improved optical properties. The measurements were performed using a UV-Vis spectrophotometer in the wavelength range of 200–800 nm. The yield varied with the temperatures reaching 14.2% at 120 °C, 24.8% at 150 °C, and 17.0% at 180 °C, with 150 °C identified as the optimal temperature for maximum yield. Fluorescence imaging under UV light revealed that the photoluminescence intensity of GQDs increased with higher hydrothermal temperatures, suggesting enhanced excitation and emission processes. This optimized hydrothermal synthesis method not only improves the quantitative yield and qualitative optical properties of GQDs but also provides a cost-effective and scalable route for their production from abundant graphite precursors. The resulting GQDs exhibit low toxicity, stable photoluminescence, and tunable optical properties, making them highly suitable for applications in bioimaging, sensing, and energy storage. In conclusion, this research underscores the significant influence of synthesis parameters on the yield and optical properties of GQDs, offering a promising pathway for their large-scale production and application in advanced technologies.

Keywords: *Fluorescence, Graphite, Graphene Quantum Dots, Hydrothermal method, Quantum confinement effect.*

Novel Palm Shell-Derived Activated Charcoal for Efficient Reactive Dye Removal: A Sustainable Approach to Textile Wastewater Treatment

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Abstract

The increasing environmental issues arising from textile wastewater allow the need for efficient and sustainable remediation techniques. In the current study, the potential of activated charcoal derived from palm shells has been explored as a low-cost, eco-friendly, efficient adsorbent for the purification of reactive dye from textile wastewater. The activated charcoal was synthesized via a pyrolysis process in the muffle furnace at 400^0 C in a nitrogen atmosphere followed by a chemical activation process in NaOH media to enhance its adsorption capacity. The adsorption performance of prepared activated charcoal was investigated using Red 3BR, a reactive dye, commonly employed in the textile industry. The impact of critical process parameters like pH and dosage of adsorbent were systematically studied at room temperature (25^oC). The experimental data demonstrated that the adsorption efficiency of the activated charcoal on the reactive dye decreases with an increase in the pH with maximum removal observed under acidic environment (4 pH). Spectroscopic and microscopic characterization of the adsorbent was performed using UV-visible spectroscopy, Fourier transform infrared (FTIR) spectroscopy, Scanning electron microscopy (SEM), and Raman spectroscopy to confirm the successful activation and surface modification of the palm shell-derived charcoal. SEM images showed that the highly porous structure with uniform micro and mesopores while the FTIR results revealed that the reduction in -OH peak intensity (3200-3500cm^{-1}) which related to the dye interaction with hydroxyl groups and a small shift in C=O peak indicating hydrogen bonding between dye molecules ad adsorbent surface. Therefore, in the current study, activated charcoal prepared from palm shells has been revealed as a superior alternative for the removal of Red 3BR dye from wastewater based on the adsorption spectra from the UV-visible spectroscopy, opening a new gateway to the utilization of waste weeds for the purpose of wastewater treatment. Due to the microporous structure, the dye is more selective towards reactive dyes like Red 3BR. This study contributes to an increasing number of studies on adsorbent-based wastewater treatment and highlights the effectiveness of converting palm shell waste into high-performance material for environmental remediation.

Keywords: *Red 3BR, Palm shells, Activated charcoal, Textile wastewater treatment*.

Environmentally Friendly Synthesis of ZVI Nanoparticles Using Green Tea and Ilmenite

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Abstract

This study highlights an eco-friendly methodology for synthesizing zero-valent iron (ZVI) nanoparticles directly from natural ilmenite ($FeTiO_3$) using natural tea extract as both a reducing and stabilizing agent. The process powers the phytochemical properties of tea, particularly polyphenols compounds, to achieve the reduction of Fe^{3+} ions to Fe^0 while simultaneously stabilizing the resultant nanoparticles. The rigid perovskite structure of ilmenite present in mineral sands was breakdown through a revolving hydrothermal process under low-temperature and mildly acidic conditions, facilitating the dissolution of iron and titanium fractions into a leachate containing iron chloride. This leachate, in combination with green tea extract, was utilized as the precursor for the synthesis of ZVI nanoparticles. The synthesized ZVI nanoparticles were characterized using advanced techniques. X-ray diffraction (XRD) confirmed their crystalline structure with minor phases of magnetite (Fe_3O_4) and iron hydroxides ($Fe(OH)_2$). Scanning electron microscopy (SEM) revealed spherical nanoparticles with high dispersion, despite some agglomeration due to their small size and magnetic interactions. Fourier transform infrared (FTIR) spectroscopy identified hydroxyl, carbonyl, and carboxylic groups from the tea extract, which contributed to nanoparticle capping and stabilization. Energy-dispersive X-ray spectroscopy (EDX) and particle size analysis further verified the core-shell structure, with an average particle size of approximately 150 nm. The synthesized ZVI nanoparticles, characterized by a high surface area, demonstrated significant potential for environmental remediation. Preliminary studies confirmed their efficiency in removing industrial dyes and chemical contaminants from aqueous solutions, attributed to their high reactivity, surface activity, and stabilization by functional groups introduced during synthesis. This study highlights a green, cost-effective synthesis approach using raw materials, emphasizing the applicability of ZVI nanoparticles in wastewater treatment and environmental remediation. These findings underscore their role as a sustainable solution for pollutant removal and as a foundation for advancing eco-friendly nanotechnology.

Keywords: *Green tea extract, Natural ilmenite, Polyphenols, Zero Valent iron*

Pine Needle Biochar as a Precursor for Carbon Quantum Dots (CQDs) Synthesis: Influence of Pyrolysis Temperature

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Abstract

Carbon quantum dots (CQDs) have emerged as promising nanomaterials in sensing, bioimaging, energy storage and conversion, catalysis, optoelectronics, and environmental applications due to their unique optical properties, biocompatibility, and eco-friendly synthesis routes. This study used biochar derived from pine needles that pyrolyzed at three different temperatures to investigate the effect of precursor temperature on CQDs synthesis. The fresh dried pine needles were pyrolyzed at 300°C, 500°C, and 700°C temperatures for two hours with a 5°C per minute heating rate using a muffle furnace. The pyrolyzed biochar at each temperature was subjected to hydrothermal treatment to synthesize CQDs. A 2.5 g biochar sample, which was dissolved in 300 mL distilled water, was autoclaved at 190°C temperature for 3 hours at 14 rpm to synthesize CQDs. The resulting material was analyzed using UV light and a particle size analyzer (Litesizer^{TM} 500, Austria). All three materials derived from hydrothermal treatment showed a blue fluorescence under UV light (365 nm). The hydrodynamic diameters of synthesized CQDs by three types of biochar precursors at 300°C, 500°C, and 700°C were 546.6 nm, 351.4 nm, and 279.3 nm, respectively. This hydrodynamic diameter of CQDs varied with pyrolysis temperature, indicating a different surface functionalization on CQDs. The findings suggest that the pyrolyzed temperature of CQD precursors affects the properties of CQDs. Since biochar is an environmentally friendly precursor and the application of the hydrothermal method, this study highlights a sustainable approach to synthesizing CQDs from biochar at different temperatures, contributing to the development of green nanotechnology for specified application purposes by controlling their surface functionalization.

Keywords: *carbon quantum dots, biochar-derived nanomaterials, green synthesis, hydrodynamic diameter, pyrolysis temperature*

An Experimental Study on Performance Degradation of Solar PV Systems Caused by Natural Soiling: A Case Study in Belihuloya, Sri Lanka

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Abstract

Solar photovoltaic (PV) systems are one of the most widely used renewable energy sources worldwide, directly converting solar irradiance into electrical energy. However, their performance can be affected by various environmental factors, with natural soiling being among the most significant. This study investigates the impact of natural soiling on the performance of solar PV panels in Belihuloya, Sri Lanka. An indoor experimental setup was developed using a 560 W monocrystalline solar panel and 500 W halogen lights, which provided an average irradiance of 200 W/m². Dust accumulation on the PV panels was simulated in a controlled indoor environment using a manual spreading method, reflecting real-world dust accumulation data analysed from the Belihuloya region, where the weekly soil accumulation rate is 3 g per panel. The efficiency of the solar panels was measured at four different dust accumulation weights: 3 g, 6 g, 9 g, and 12 g. Efficiency was determined by comparing the irradiance energy input with the PV panel output power values. The temperature was maintained at approximately 27°C. Initially, the cleaned panel had an efficiency of **7.96%.** The efficiencies at different soiling levels were observed as **7.60%, 7.39%, 7.19%, and 6.86%** for **3 g, 6 g, 9 g, and 12 g** of dust accumulation, respectively. The results indicate a **declining efficiency trend** as dust accumulation increases. The efficiency drop between the fully cleaned panel and the **12g dust-accumulated** panel was **1.10%.** This study provides valuable insights into the impact of soiling on the performance and efficiency of PV modules in the Belihuloya region of Sri Lanka, highlighting the importance of implementing effective dust cleaning strategies to enhance solar panel performance.

Keywords: *Dust Accumulation, PV Indoor experiment, Photovoltaic modules, Soiling effect, Solar PV Efficiency*

Experimental Analysis of Optimal Cleaning Methods for Natural Soiling on Solar PV Modules Using FTIR Spectroscopy

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Abstract

Dust accumulation significantly reduces the efficiency of a PV module, and the lack of an economically sustainable and efficient cleaning solution is a recurring problem. This study illustrates the identification of the types of bonds in dust samples collected from the Belihuloya region in Sri Lanka and recommends the most effective cleaning medium for removing dust from solar panel (PV) modules. Dust samples were collected from solar panels installed at Sabaragamuwa University of Sri Lanka and then analyzed using Fourier Transform Infrared (FTIR) spectroscopy to identify chemical bonds present in the contaminants. The analysis revealed the presence of specific bond types, including O-H cellulose (3640cm^{-1}), (p)O-H groups (2060cm^{-1}), Si-O (1030cm^{-1}), C-Cl halides (718cm^{-1}), and C-Br halides (549cm^{-1}), which contribute to the dust's adhesive properties and its impact on solar panel performance. The hydroxyl (-OH) groups in cellulose and other organic compounds exhibit strong hydrogen bonding, which, when accumulated, makes stronger attachment of dust particles to the panel surface. Similarly, (Si-O) groups contribute to dust aggregation due to their polar nature. The presence of halides (C-Cl and C-Br) indicates inorganic contaminants, which may increase the dust deposition on solar (PV) panels. Based on these chemical characteristics, water-based cleaning is proposed as the most efficient medium for dust elimination. Water molecules (H_2O) can disrupt hydrogen bonding within the O-H and Si-O functional groups, reducing the stickiness of dust particles. This cleaning medium provides an efficient, cost-effective, and environmentally friendly approach to maintaining PV module efficiency by reducing dust accumulation and the performance problems it causes in the Belihuloya region.

Keywords: *Dust Accumulation, PV Indoor experiment, FTIR Spectroscopy, natural Soiling effect, Solar PV Efficiency*

Microplastics Removal Using Nano-Magnetite in Aqueous Medium

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Abstract

Microplastics (MPs) are emerging global contaminants and have been extensively detected in aqueous environments, threatening the well-being of living organisms and the natural environment. Existing MPs removal techniques, including physical, chemical, and biological methods, are inefficient in removing MPs, necessitating an innovative and effective removal strategy. This study explores the potential of nano-magnetite in the removal of MPs through magnetic separation. The impact of varying experimental conditions, such as nano-magnetite concentration (0.1 - 4.3 g L^{-1}) and polyethylene MPs concentration (0.1 – 1.5 g L^{-1}), is demonstrated where the assessment of MPs removal efficiency was experimented by attracting the magnetized MPs out of the medium using a magnet. The resulting solution residue was characterized using Fourier Transform Infrared Spectroscopy (FTIR) in Attenuated Total Reflectance (ATR) mode. Nano-magnetite is proven to be an effective adsorbent for MPs, achieving a maximum removal efficiency of 92% under optimized conditions of 1.5 g L^{-1} nano-magnetite and 0.5 g L^{-1} polyethylene MPs with 120 min oscillation treatment. The FTIR spectrum of the solution residue showed the characteristic peaks for C-H bonds (2914.08 cm^{-1}), confirming the adsorption of magnetite onto MPs and its possibility of removal. The attachment of magnetite nanoparticles to MPs occurs through multiple mechanisms, including electrostatic, van der Waals, and hydrophobic interactions, enabling magnetic separation. In conclusion, this study highlights the potential of nano-magnetite in the efficient removal of MPs in water and the possibility of its integration into existing water treatment technologies. Further investigations are needed to assess MPs removal with counter ions and natural organic matter to simulate real-world conditions.

Keywords: *Counter ions, magnetic separation, natural organic matter, plastics, sorption*

Structural and Chemical Modifications of Heat-treated Tourmaline under Oxidizing Environments

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Abstract

Tourmaline, a complex borosilicate mineral, exhibits various trace elements. Yellow, green, and bi-coloured tourmaline are found in Sri Lanka. Sri Lankan-originated tourmalines have high iron content, are translucent or opaque, and have limited commercial value, therefore need value addition (enhance colour and clarity) before sale. This study investigates the structural and chemical changes in translucent and opaque Sri Lankan tourmaline subjected to heat treatment at 800°C and 900°C for 3- and 6-hour soaking times in a muffle furnace. Samples were analyzed using a Fourier Transform Infrared (FTIR) spectrometer (Collector II) before and after the heat treatment. The FTIR band ~500 cm^{-1} responds to Fe–O vibrations exhibited a moderate decrease in the intensity with increasing temperature, indicating the oxidation of Fe^{2+} to Fe^{3+}. The band ~600 cm^{-1} associated with Mn–O vibrations decreased intensity, showing oxidizing number change of Mn from the tourmaline structure. The Mg–O vibrations ~450 cm^{-1} decreased slightly, indicating minor changes in Mg. The Al–O vibrations remained stable, showing structural stability of Al in the mineral. The 1000–1200 cm^{-1} region, corresponding to Si–O stretching vibrations shifted to higher wavenumbers with increasing temperature. The band ~3500 cm^{-1} attributed to OH stretching vibrations and band at ~1650 cm^{-1} associated with H–O–H bending vibrations exhibited a significant decrease in intensity, reflecting trapped water removal from intrusions due to dihydroxylation. Heat-treated translucent samples become opaque, forming a red oxide layer on surface after 3 hours of soaking at 800°C. The findings suggest shorter soaking times at higher temperatures in oxidizing environments are unsuitable for Sri Lankan-origin tourmaline. These findings contribute to a deeper understanding of tourmaline's thermal behavior. Future studies should focus on heat treatments conducted in reducing environments at temperatures below 800°C for longer soaking time.

Keywords: *Tourmaline, Heat treatment, FTIR spectroscopy, Structural and Chemical Modifications*

Applied Biotechnology and Microbiology

Isolation of Cellulolytic Termite Gut Bacteria and Soil Fungi and The Kinetic Comparison of *Aspergillus Niger* and Commercial Cellulase

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Abstract

The isolation and screening of cellulolytic bacteria from termite gut and fungi from soil were conducted using enrichment media and Congo red staining on Carboxy Methyl Cellulose (CMC) agar plates. Isolates with a Cellulolytic Index (CI) > 4 were selected for cellulase production using CMC and pretreated *Parthenium hysterophorus* biomass as carbon source in enzyme production medium for bacterium and fungal strains respectively. Crude enzyme extracts underwent partial purification through $(NH_4)_2SO_4$ (70%) precipitation and dialysis, followed by enzyme activity evaluation using the DiNitro Salicylic Acid (DNS) assay. Optimization of assay conditions was performed using the one-factor-at-a-time approach. The effect of metal ions on enzyme activity and stability was assessed by adding metals to the reaction mixture and preincubating the enzyme with metal ions. Kinetic characterization of *Aspergillus niger* and commercial cellulase was performed using Lineweaver-Burk plots. The unit activities of crude enzyme were 1.513 and 0.5257 (in $mgmL^{-2}min^{-1}$) for termite gut bacterium and *Aspergillus niger* respectively. Increased values of 1.679 and 1.1272 (in $mgmL^{-2}min^{-1}$) were observed for the same with the partially purified enzymes. Optimal pH and temperature for *A. niger* and commercial cellulase were 5.0, 4.8 and 70°C, 50°C, respectively. Among the metal ions investigated, Mn^{2+} and Fe^{2+} enhanced activity of *Aspergillus niger* and enhanced enzyme stability was observed with Mn^{2+}, whereas Na^{+}, Ca^{2+}, Cu^{2+} and EDTA showed inhibition. *Aspergillus niger* cellulase exhibited superior catalytic efficiency with a higher Vmax (0.9432 mg mL^{-2} min^{-1}) and lower Km (1.1078 g L^{-1}) compared to commercial cellulase (Vmax: 0.7657 mg mL^{-2} min^{-1}, Km: 7.3510 g L^{-1}). All experiments were conducted in triplicate to ensure accuracy and reproducibility. This study establishes termite gut bacteria as a promising alternative for enzyme production under optimized conditions. Additionally, *Aspergillus niger* cellulase outperforms commercial cellulase in catalytic efficiency and a promising enzyme to be used in diverse industries where rapid substrate breakdown is essential.

Keywords: *Aspergillus niger, Cellulase, Cellulolytic index, Enzyme activity, Kinetics*

Assessment of Growth, Flowering, and Plumbagin content in *Plumbago indica* L.: Tissue Culture vs. Conventional Propagation

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Abstract

Plumbago indica L. (Indian leadwort), a perennial shrub of the family Plumbaginaceae, is valued for its ornamental and medicinal properties due to plumbagin, a bioactive compound concentrated in the roots. Overharvesting and unsustainable collection have caused a decline in natural populations and conventional propagation is challenging due to slow growth and low seed viability. This study aimed to acclimatize in vitro regenerated plantlets (optimized through direct organogenesis) and compare growth, flowering habits, root biomass, and plumbagin content of tissue-cultured and conventionally propagated plants. Surface-sterilized nodal segments cultured on MS medium with 2.0 mg/L BAP induced shoots, which were elongated on MS medium with 4.0 mg/L GA_3 and rooted with 0.4 mg/L IBA. Rooted plantlets were acclimatized in coir pellets and later transferred to soil (topsoil:compost, 1:1). Survival percentages, plant height, branches, flowering time, and root weights were assessed over eight months. Phytochemicals were extracted into ethanol using soxhlet and HPLC was used to analyze plumbagin content. Tissue-cultured plants showed 100% and 90% survival in coir pellets and soil, respectively. Their mean height (P=0.00) and branch number (P=0.01) after eight months were 116.80±9.03 cm and 7.50±1.84, compared to 145.00±12.90 cm and 5.30±1.42 for conventionally propagated plants. Flowering began at 15–24 weeks for tissue-cultured plants, later than the 15–16 weeks observed in conventionally propagated plants. Mean fresh (P=0.57) and dry root weights (P=0.50) for conventionally propagated plants were 56.90±11.19 g and 17.33±3.15 g, non-significantly higher than the 53.21±16.85 g and 16.04±5.05 g of tissue-cultured plants. Plumbagin content was 23.53±5.34 µg/mL (2.35%) in conventionally propagated roots and 12.90±2.42 µg/mL (1.29%) in tissue-cultured roots. While in vitro culture shows promise for plumbagin production, enhancement strategies are needed for sustainable phytochemical yields.

Keywords: *Acclimatization, flowering habit, Plumbagin, Plumbago indica, tissue culture*

Feasibility Analysis of Single Stage Anaerobic Digestion Compared to Multi Stage AD in a Lab Scale Setup Under Controlled Conditions for Industrial Prospects

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Abstract

Anaerobic digestion is a very prominent technology for waste management which includes the treatment of organic waste producing renewable energy. Simple design and operation are the reason why single-stage digesters are more popular. However, it has been suggested that multi-stage systems may work better, with increased substrate degradation and microbial specialization. In this study, the feasibility and relative performance of single-stage and multi-stage AD systems will be investigated at lab-scale under mesophilic conditions (35°C). This is a critical problem that can multi-stage anaerobic digestion systems achieve greater biogas yields and purity of methane as compared to single-stage systems. Five substrate mixtures were formulated in this study, including poultry manure, fish waste, chicken waste, beef, and cactus. Batch reactors were operated for single-stage and multi-stage configurations. The multi-stage systems separated hydrolysis/acidogenesis from methanogenesis, designed to bring about optimal performance by each microbial community. Functional indicators taken were the total biogas volume, CH_4 content, volatile solids reduction, and those indicators of process stability, PH and accumulation of volatile fatty acids. For example, Batch 3 (chicken waste: fish waste: poultry manure: beef, 25:25:25:25) gave 950 ml of biogas from a multi-stage system compared to 650 mL from single-stage systems. The methane content in multi-stage systems was as much as 76.7% (Batch 3) versus 43.2% in single-stage systems. The VS reduction again was far more with multi-stage systems ranging from 65% to 75% versus 45% to 55% in single-stage systems. Multi-stage reactors still proved to be the most stable, as pH fluctuations were mostly held between 6.8 and 7.2 and VFA accumulation was not high. Researchers conclude that multi-stage AD systems offer better biogas production and process efficiency. In the future, the focus should be put on scaling up the multi-stage reactor, improving real-time monitoring technologies, and developing integrated industrial waste management systems which can also serve to maximize renewable energy outputs.

Keywords- *Anaerobic Digestion, Methanogenesis, Single Stage, Multi Stage, Volatile Fatty Acids*

Identified Plant Pigments for Colorizing a Natural PH Indicator to Manipulating the PH of Bio Energy Processes as a Sustainable Process Improvement

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Abstract

This research investigates the use of herbs and plant dyes as permanent PH indicators for changing the pH phase in anaerobic processes. It addresses the challenges of synthetic PH indicators, which raise environmental and safety concerns. The objective is to identify, extract and evaluate plant pigments for pH sensitivity and to integrate environmentally friendly products with paper substrates for sensitive applications. Pigment extracts from flowers, fruits and vegetables such as *Tabernaemontana divaricata*, *Clitoria ternatea*, *Impatiens balsamina*, *Catharanthus roseus* have been tested for acidic, neutral and basic color changes using a Ph meter and UV visible spectroscopy. These pigments are also used in the paper making process to investigate their incorporation into pH-sensitive functional materials. Methods include extracting the pigments using alcohol-based solvents, titration for pH testing and paper preparation and treatment with combined dyes to assess stability and reactivity. The finding explains that pigments such as those from *Clitoria ternatea* and *Impatiens balsamina* show excellent color behavior with pH changes. Papers dyed with these types of pigments consist of Ph sensitive characteristics, keeping potential application in Environmental testing and Renewable bio energy systems. Pigments came from *Beta vulgaris* and *Curcuma longa* showed limited variations and reactivity but provided stable colorization. This research work was helpful to replace synthetic pH indicators with bio synthetic alternatives with joining to sustainability in material science and waste management. They can be used to evaluate the pH variation through the retention time of inserted substrate in Anaerobic system. Future direction consists of enriching the long-term stability of pigments in diverse matrices, optimizing extraction and manufacturing for industrial usability and evaluating their consumption in Anaerobic digestion systems and Digestate management systems to increase process control and efficiency. The involvement of natural pigments provides a promising pathway toward environmentally responsible innovation in green chemistry.

Keywords *– Bio Energy, Diagnostics, PH Indicators, UV visible spectroscopy, Renewable Energy*

Characterization and Comparative Analysis of Pomelo (*Citrus maxima*) Peel Essential Oil Using Soxhlet Extraction and Hydrodistillation

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Abstract

Pomelo (*Citrus maxima*), an underutilized fruit in Sri Lanka, holds significant economic potential due to its distinct flavor and nutritional value. Its peel, a major by-product accounting for nearly 50% of the fruit's weight, is a rich source of essential oils with applications in the food, cosmetic, and pharmaceutical industries. This study aims to assess the influence of two different extraction methods on the isolation of oil from pomelo peel, evaluating their chemical composition and bioactivity. Soxhlet extraction with hexane and hydrodistillation were used to extract the oil from pomelo peel and GC-MS was used to analyze the chemical composition. The extracted oils were further evaluated for total phenolic content using the Folin-Ciocalteu method, antioxidant activity using the DPPH and ABTS assays, and antibacterial activity against three food-borne pathogenic bacteria (*Staphylococcus aureus*, *Bacillus cereus*, and *Escherichia coli*) using disc diffusion method. The results revealed that Soxhlet extraction provides a significantly higher oil yield ($p<0.05$) compared to hydrodistillation, 2.02 ± 0.74% and 1.18 ± 1.26%, respectively. GC-MS analysis identified limonene as the main monoterpene hydrocarbon in both oil extracts ranging from 29.32% for Soxhlet extraction to 86.98% for hydrodistillation. This suggests that hydrodistillation preserves volatiles, while Soxhlet extraction enhances both volatile and non-volatile bioactive compounds. According to the total phenolic content, Soxhlet-extracted oil (12.96 ± 0.38 mg GAE/g) showed a higher value compared to hydrodistilled oil (6.04 ± 0.67 mg GAE/g). DPPH and ABTS assays followed a similar trend with Soxhlet-extracted oil exhibiting higher scavenging activity. Antimicrobial assays revealed that both extracted oils showed significantly higher inhibition for gram-positive bacteria ($p<0.05$) than gram-negative bacteria. The study emphasizes the potential of pomelo peel oil as a high-value, sustainable natural resource for diverse industrial applications, highlighting the effect of extraction methods to optimize the recovery of bioactive compounds.

Keywords: *Citrus maxima, essential oil, GC-MS analysis, hydrodistillation, Soxhlet extraction*

Studying the Antibiotic-Resistant Patterns of Bacteria Isolated from Commercially Available Chicken Manure Samples

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Abstract

Chicken manure is widely applied as a fertilizer in agricultural fields in Sri Lanka. However, the extensive usage of antibiotics in the chicken farming industry may carry a risk of having soil contaminated with antibiotic residues and antibiotic-resistant bacteria. This may increase the potential threat to public health due to the mobilization of antibiotic resistance within bacterial populations. In this study, antibiotic-resistant bacteria were isolated from commercially available chicken manure samples, and the antibiotic-resistant profiles of these isolates were studied. Two chicken manure samples obtained from Kosgama and Beruwala were used to isolate a total of 20 antibiotic resistant bacteria using nutrient agar supplemented with ampicillin (50 μgmL^{-1}), tetracycline (30 μgmL^{-1}) and kanamycin (30 μgmL^{-1}) separately. Antibiotic resistance of selected isolates was determined using a standard well diffusion assay with 3 different concentrations (100, 150 and 200 μgmL^{-1}) of each of the antibiotic used. The multidrug-resistant isolates, exhibiting resistance to the highest concentrations of all three antibiotics tested, were selected for further analysis. These isolates were subsequently exposed to higher concentrations of ampicillin, tetracycline, and kanamycin (200, 250, and 300 μgmL^{-1}), as well as chloramphenicol, erythromycin, and rifampicin (100 and 150 μgmL^{-1}). Out of the antibiotic-resistant bacterial isolates, 50% were resistant to 2 or more antibiotics tested, while 20% of the isolates were resistant to all 3 antibiotics at 200 μgmL^{-1} concentration. Among the selected multidrug-resistant isolates (S1AmpC4, S1KanC2, S1TetC3 and S1TetC4), S1AmpC4 exhibited resistance to ampicillin (300 μgmL^{-1}), kanamycin (300 μgmL^{-1}) and chloramphenicol (150 μgmL^{-1}). S1TetC3 exhibited resistance to ampicillin (300 μgmL^{-1}), tetracycline (300 μgmL^{-1}), kanamycin (300 μgmL^{-1}) and erythromycin (150 μgmL^{-1}) and S1TetC4 exhibited resistance to ampicillin (300 μgmL^{-1}), tetracycline (300 μgmL^{-1}) and erythromycin (150 μgmL^{-1}). Isolate S1AmpC4, S1TetC3, S1TetC4 were resistant to four out of six antibiotics used. The results of this study suggest that the application of untreated chicken manure to the soil can facilitate the mobility of antibiotic resistance through the ecosystem via these multidrug-resistant bacteria.

Keywords: *Antibiotics, Antibiotic resistance, Chicken manure, Multi antimicrobial drug resistance*

Impact of Deacetylation Duration on the Characteristics of Chitosan Derived from Crab Shells

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Abstract

Chitosan is a biopolymer that is a potential source of water remediation due to its physical and chemical properties. It offers high potential for eco-friendly and environmentally safe due to its biodegradability, biocompatibility, and nontoxicity. This study investigates the effects of reaction time of deacetylation on the characteristics of chitosan. Chitosan was synthesized from crab shells (*Callinectes sapidus*). Chitosan was synthesized using chemical treatment followed by demineralization, deproteination and deacetylation using 2M HCl, 2M NaOH and 50% NaOH, respectively. Chitin was derived after demineralization and deproteination of crab shells. Deacetylation was done at 150 ℃ for 60, 120, 180, 240 and 300 minutes. The chitin and chitosan were characterized using the Fourier Transform Infrared-Attenuated Total Reflectance (FTIR-ATR) spectroscopy method and particle size was analyzed using a particle size analyzer. The degree of deacetylation (DD%) of synthesized chitosan at 150 ℃ for 60, 120, 180, 240 and 300 minutes was increased while increasing the reaction time. The particle sizes of synthesized chitosan at 150 ℃ for 60, 120, 180, 240 and 300 minutes were reduced from ≥2 µm to 882 nm while increasing the reaction time. According to the results, the highest degree of deacetylation was found at 150 ℃ for 300 minutes, resulting in a high purity of chitosan. The high purity of chitosan, indicating higher DD% has the potential to adsorb contaminants from water efficiently due to its enhanced chemical and mechanical properties.

Keywords: *Chitosan, Deacetylation, Demineralization, Deproteination, Reaction time*

Pollutant Removal Efficiency and Phytotoxicity Assessment of Textile Industry Wastewater using *Spirulina* sp.

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Abstract

Textile industry wastewater (TWW) is a significant environmental pollutant due to its high concentrations of toxic chemicals, synthetic dyes, recalcitrant organic compounds, and excess nutrients, necessitating effective treatment prior to discharge. This study investigates the potential of *Spirulina* sp., a locally isolated strain from a freshwater reservoir, for the bioremediation of TWW as a sustainable and eco-friendly alternative to conventional treatment methods. TWW samples were collected from a leading textile company in the Biyagama Export Processing Zone, Sri Lanka. A 10% (v/v) homogeneous inoculum of *Spirulina* sp. was introduced into 20 L transparent glass tanks under greenhouse conditions, maintained with continuous aeration and a 12:12 h light: dark photoperiod. Over four weeks, the growth of *Spirulina* sp. and TWW decolorization were monitored spectrophotometrically. The results revealed a growth efficiency of 83.57 ± 0.69% and TWW decolorization efficiency of 79.03 ± 0.11%, as evidenced by absorbance measurements using an ultraviolet-visible spectrophotometer. The study recorded a significant chemical oxygen demand (COD) removal of 93.11 ± 1.14%, indicating the bioremediation potential of *Spirulina* sp. Ammoniacal nitrogen, nitrate, and phosphate removal efficiencies were recorded as 96.86 ± 0.79%, 73 ± 0.97%, and 33.33 ± 1.13%, respectively. The lower phosphate removal efficiency suggests that phosphorus in TWW may be in a less bioavailable form for *Spirulina* sp. To evaluate the phytotoxicity of the treated TWW, a seed germination assay using green gram (*Vigna radiata)* was conducted. After five days, a 75% seed germination rate was observed in *Spirulina*-treated TWW compared to the untreated TWW, with shoot and root development of 5.13 ± 0.08 cm and 4.42 ± 1.47 cm, respectively. Overall, this study highlights the efficacy of *Spirulina* sp. in pollutant removal and the potential reuse of treated wastewater for irrigation, promoting plant growth and contributing to sustainable wastewater management practices.

Keywords: *Bioremediation, Phytotoxicity, Pollutant removal, Spirulina sp., Textile wastewater*

Identification of Tolerance Levels of Groundnut Genotypes to *Aspergillus flavus*

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Abstract

Groundnut (*Arachis hypogaea* L.) is a globally important oilseed crop, but its productivity is severely affected by *Aspergillus flavus* infection, which produces aflatoxins harmful to human and animal health, leading to economic losses. This study aimed to screen ten groundnut genotypes for resistance and susceptibility to *A. flavus* infection through morphological and physiological traits under controlled conditions. Diseased groundnut kernels with *A. flavus* symptoms were collected, surface-sterilized, and plated on PDA for incubation and dentification was based on colony color, conidial arrangement, and microscopy. A pot experiment was conducted using a Randomized Complete Block Design (RCBD) with four replicates. Groundnut seeds of different genotypes were planted in *A. flavus*-inoculated and non-inoculated soil. Leaves and seeds were collected for *in vitro* screening. Fungal growth and necrotic lesion were measured on leaves and seeds were assessed for fungal colonization percentage and infection rates. Data were analyzed using one-way ANOVA in Minitab. The results revealed significant variation among the genotypes in their response to *A. flavus*. Under *in vitro* screening, ANKG SR1 and ANKGN-4 exhibited the highest fungal colonization (89.19±0.5% and 73.05±0.6%, respectively) and necrotic lesion areas (100.00±0.0% and 91.26±0.8%), indicating high susceptibility. Tissa (17.54±1.0 %) and Lanka Jumbo (0.00±0.0%) showed the lowest fungal colonization and no necrotic lesions demonstrating strong resistance. Fungal colonization was highest on the seeds of ANKG SR1 (74.94%) and ANKGN-4 (78.70%), while significantly low in Tissa (26.25%) and Lanka Jumbo (29.00%). Seeds from non-inoculated but damaged plants showed no infection. These findings highlight the genetic diversity of groundnut genotypes in *A. flavus* resistance. Tissa and Lanka Jumbo were identified as the most resistant genotypes, making them ideal candidates for breeding aflatoxin-resistant varieties. This study provides valuable insights for breeding programs aimed at enhancing food safety and sustainable crop production.

Keywords: *Aflatoxin resistance, Arachis hypogaea, Aspergillus flavus, Breeding programs, Groundnut genotypes*

Feasibility Study on the Green Synthesis of CuO Nanoparticles Using *Tithonia diversifolia* (Wild Sunflower) Leaf ExtractS.S. Millavithanachchi[1,2,3], M.D.K.M. Gunasena[1,3*], K.R. Koswattage[3,4], D.V.S. Kaluthanthri[5], P.K.G.S.S. Bandara[1], G.D.C.P. Galpaya[3], K.M. Jambugaswaththa[1], V. Kirthika[3] and A.M.P. Hansini[3]

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Abstract

The synthesis of nanoparticles has gained significant attention due to their diverse applications in agriculture, technology, and electronics. Traditional chemical methods involve harsh conditions, leading to the rise of green synthesis as an eco-friendly alternative. *Tithonia diversifolia*, commonly known as wild sunflower, is native to Mexico and invasive in Sri Lanka. This study explores its potential use in CuO nanoparticle synthesis, converting an environmental threat into a valuable resource. Copper sulfate ($CuSO_4$) was chosen as a cost-effective precursor instead of noble metals like Ag and Au. Leaves were washed, dried, ground into powder, and 5 g was dissolved in 50 mL of distilled water (1:10). After continuous stirring at 70°C, the mixture was filtered and centrifuged at 10,000 rpm for 10 minutes. The supernatant was used for nanoparticle synthesis by mixing 0.5M $CuSO_4$ solution, plant extract, and distilled water in a 1:1:1 ratio. Reactions were conducted at 70°C for 15 minutes and room temperature for 45 minutes. A color change to brown indicated nanoparticle formation. Characterization techniques included UV-Visible spectrophotometry, Scanning Electron Microscope (SEM), Fourier-Transform Infrared Spectroscopy- Attenuated Total Reflectance (FTIR-ATR), zeta potential, and particle size analysis. The UV spectrum ranged from 200–400 nm, while SEM revealed polygonal and spherical nanoparticles with some aggregation (~125 nm). FTIR-ATR gave peaks near to the 600 cm^{-1}. According to the particle size analyzer, average particle size was 240 nm, with 0.25 µm filter used to remove larger aggregates. Low zeta potential value indicated moderate stability, though some degree of aggregation was observed, suggesting the need for further optimization. This study confirms the feasibility of synthesizing CuO nanoparticles using *T. diversifolia*. However, optimization is needed to reduce aggregation and improve stability. The method is cost-effective and environmentally friendly, showing promise for future applications in green nanotechnology.

Keywords: *Characterization, CuO nanoparticles, green synthesis, nanobiotechnology, Tithonia diversifolia*

Evaluating the Efficacy of *Beauveria bassiana* in Controlling *Deltocephalus menoni* (Hemiptera: Cicadellidae), the Vector of Sugarcane White Leaf Disease

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Abstract

Sugarcane (*Saccharum* spp. *hybrids*) is the only crop used for sugar production in Sri Lanka. Sugarcane White Leaf Disease (WLD) is a serious threat to sugarcane production, increasing fiber content while reducing juice volume, pure extractable cane sugar (POCS), and overall production. The only known vector of WLD is *Deltocephalus menoni* (Hemiptera: Cicadellidae) which is a sap-sucking insect. To reduce the spread of the disease, effective management of the WLD vector is essential. This study explores the potential of using *Beauveria bassiana* as a biological control agent for *D. menoni.* The fungus *B. bassiana* was isolated from *Phyllilla perpusilla* collected from the research farm of Sugarcane Research Institute Uda walawe, Sri Lanka, under the laboratory rearing, during the Yala season in August 2024. *B. bassiana* isolates were identified through morphological features and confirmed by microscopic examination and ITS region amplification using ITS1 and ITS4 primers. The amplified product typically measured about 545 base pairs (bp) which is widely used for the identification of *B. bassiana*. The fungus was cultured and identified on PDA medium, and spore multiplication was performed on PDB medium. A fungal pathogen bioassay was conducted using five concentrations of *B. bassiana* spore suspensions (10^1,10^3,10^5,10^7, and 10^9 spores/ml), quantified using a hemocytometer and sprayed to inoculate the vectors. The progression of infection was monitored and recorded at 3,5,7,10, and 15 days after application. A group of insects treated with sterile water was maintained as control for comparison. Postmortem examination of dead insects was performed to confirm *B. bassiana* infection through mycelial growth. Median lethal concentration (LC_{50}) and ANOVA followed by Tukey test, was performed at 5% probability to determine the effective spore concentration using SAS 0.9 software. Lowest LC_{50} value (0.96) observed on day 7 and 10^5 spores/ml was the most effective concentration. The results demonstrate the concentration-dependent efficacy of *B. bassiana* in managing *D. menoni.* These findings further highlight the potential of *B. bassiana* as a sustainable alternative to chemical pesticides for controlling WLD vectors in sugarcane fields.

Keywords*: Entomopathogenic fungi, Sri Lanka, Sugarcane Disease, Vector management*

Activity analysis of extracellular α-amylase enzyme produced by *Anoxybacillus caldiproteolyticus*, a thermophilic bacterium isolated from Nelumwewa hot water spring.

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Abstract

α-Amylase is an enzyme that digests starch into smaller molecules like maltose and glucose. This study investigated the activity of extracellular α-amylase enzyme produced by *Anoxybacillus caldiproteolyticus*, a thermophilic bacterium isolated from Nelumwewa hot water spring located in the Polonnaruwa District, Sri Lanka. The hot spring, with a temperature of approximately 65°C, provides an ideal environment for thermophilic microorganisms. The primary objective of this research was to isolate, identify, and evaluate the α-amylase activity of *A. caldiproteolyticus* using the 3,5-Dinitrosalicylic Acid (DNS) assay, a widely recognized method for quantifying reducing sugars generated during enzymatic starch hydrolysis. The bacterium was cultured overnight in 500 ml of nutrient broth at 60°C by shaking at 100 rpm using shaking incubator, and for activity analysis, the crude extracellular enzyme was extracted by centrifuging the culture broth at 10000 rpm for 10 minutes. The DNS assay revealed the crude α-amylase activity of 0.5 Uml^{-1}, indicating the enzyme's potential for industrial applications requiring high thermal stability. This finding is significant as thermostable α-amylases are highly sought after in biotechnology industries such as biofuel production, food processing, and detergent manufacturing, where enzymes must withstand harsh operational conditions. This study highlighted the biotechnological potential of thermophilic bacteria from understudied geothermal environments of Sri Lanka. In conclusion, this study demonstrates the potential of *A. caldiproteolyticus* as a promising source of thermostable α-amylase, contributing to the growing interest in thermophilic microorganisms for industrial enzyme production.

Keywords: *Thermophilic bacteria, Anoxybacillus caldiproteolyticus, Thermostable enzymes, α-amylase enzyme, Nelumwewa hot water spring.*

Optimization of Primer Annealing Temperature for qPCR Detection and Quantification of White Leaf Disease Causing Phytoplasma in Sugarcane

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Abstract

Sugarcane White Leaf Disease (WLD) caused by a phytoplasma is one of the major threats in sugarcane plantations in Sri Lanka and affects adversely on both crop yield and quality. This disease adversely affects sugarcane growers and sugar manufacturers by decreasing crop productivity and reducing economic profitability. WLD is primarily transmitted through infected seed cane and secondarily by sap-sucking insect vectors. This study aimed to optimize the primer annealing temperature for qPCR detection and quantification of WLD causing phytoplasma in sugarcane. This phytoplasma was identified through standard PCR technique using a specific primer pair, SPP1 (forward) and SPP2 (reverse), which produced the expected amplicon size of 321 bp in all WLD affected samples. qPCR was employed to detect and quantify the amplified phytoplasma DNA using the same primer pair. A gradient PCR was performed using a qPCR machine across six annealing temperatures ranging from 50.3 °C to 58.7 °C, with increments of 1.7 °C, to determine the optimal annealing temperature. The experiment was conducted twice in duplicate to enhance the detection sensitivity and accuracy. Based on cycle threshold (Ct) values and melting curve analysis, the annealing temperature of 55.4 °C demonstrated the highest efficiency and specificity for the SPP1 and SPP2 primer pair. These findings establish a reliable protocol for the precise detection and quantification of phytoplasma in sugarcane, facilitating the effective management of WLD. The implementation of this approach enables early and accurate diagnosis, contributing to the containment of disease spread and enhancing the sustainability of sugarcane production in Sri Lanka and other affected regions.

Keywords: *Primer Annealing temperature, Phytoplasma, qPCR, Sugarcane, White Leaf Disease*

Assessment of the Feasibility of Producing Fiber-Enriched Pasta from Sugarcane Bagasse

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Abstract

Sugarcane (*Saccharum officinarum*) is a crop grown in Sri Lanka, especially for sugar production. Sugarcane bagasse is a by-product of sugarcane processing. It is rich in fiber and has potential applications in food product development. The aim of this study is to develop fiber-rich pasta by incorporating sugarcane bagasse powder at five different levels (5%, 10%, 15%, 20% and 25%) along with wheat flour and salt. Sugarcane bagasse was obtained from a jaggery manufacturing plant with peel, dried, ground, sieved and a fine powder, with a moisture content of 6.96±0.00%, was obtained. The fiber content (wet weight basis) of the bagasse powder was 36.37±0.35%. Other properties analyzed included fat content (1.63±0.02%), ash content (2.07±0.63%), protein content (1.22±0.18%), reducing sugar (4.23±0.04%), carbohydrate content (51.75±0.88%), water holding capacity (6.29±0.13 g/g), oil holding capacity (10.02±0.06 g/g), organic matter absorption capacity (5.56±0.21 g/g), swelling capacity (9.82±0.59 mL/g), and water retention capacity (7.47±0.33 g/g). Pasta was prepared by mixing wheat flour and bagasse powder in the proportions of 0% (control), 5%, 10%, 15%, 20% and 25% (w/w) and adding salt, kneading the dough, rolling it out thinly, cutting into small pieces, shaping it into pasta and keeping it at 70 °C for 6 hours. Sensory evaluation revealed that pasta with 5% bagasse had the highest overall acceptability among all tested samples. The 5% bagasse-enriched pasta was analyzed for nutritional composition. The results showed fiber content (1.65±0.24%), fat content (1.90±0.06%), protein content (6.21±1.22%), ash content (2.03±0.08%), moisture content (6.00±0.19%), and carbohydrate content (82.21±1.36%). Significance set at $P \leq 0.05$. These results suggest that incorporating 5% sugarcane bagasse powder into pasta enhances fiber content without negatively affecting the product's overall nutritional profile or sensory qualities. The study indicates that sugarcane bagasse is a viable ingredient for developing healthier pasta products with improved fiber content, offering a sustainable solution for utilizing agricultural by-products

Keywords: *Fiber-enriched, Food product development, Nutritional composition, Sensory evaluation, Sugarcane bagasse*

Circulating Nutrient Solutions for Paddy Cultivation in Urban and Water-Scarce Areas

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Abstract

Rice (Oryza sativa) is the staple food in Sri Lanka and many countries. The productivity of cultivation's productivity does not fulfill the demand due to economic, technical environment, and environmental drawbacks. A circulating hydroponic system is considered an alternative paddy cultivation method that allows for the overcoming of disadvantages in traditional paddy cultivation, including areas lacking regular irrigation systems (water scarcity), spaciousness (urban areas), nutrient input, etc. This study examined the growth and the water consumption of a local rice variety (Asuuda) under traditional and circulating hydroponic 220 plantlets were planted on the rooftop conditions in a $2m^2$ area under the circulating nutrient soluble hydroponic system and sown paddy under the conventional method as a control. The experiment was conducted using a total area of $4m^2$, with seven rows of $2m^2$ area on a rooftop cultivating 220 plants, and a $2m^2$ area using the conventional method; using the same area ensures a fair comparison by removing space-related differences. The results revealed that paddy plants grown using the circulating nutrient soluble hydroponic system showed better growth potential, measured through parameters like Plant height, number of tillers per plant, water usage, pH value, and EC value while consuming less amount of water compared to paddy grown using the conventional system. The pH value was maintained at 5.5-6.5, and the EC value was maintained at 1.5-2.5mScm-1. Paddy samples grown under circulating nutrient-soluble hydroponic systems showed higher height (In nurseries, about 15cm within 7 days and after the growth stage, about 60-120cm) than those grown under conventional systems. Further analysis should be conducted to evaluate the yield and viability of paddy grown using the circulating nutrient-soluble cultivation method.

Key words: *Irrigation challenges, Nutrient soluble cultivation, Rooftop farming, Sustainable agriculture, Urban agriculture*

Assessing the Feasibility of Urban Areas with Low Water Availability Participating in Nutrient Soluble Hydroponic Paddy Cultivation: A Novel Method of Sustainable Rice Production

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Abstract

The science of hydroponic paddy cultivation is a technique through which rice crops are grown in nutrient-rich water solutions without soil, thus making it cost-effective in the use of water and making it possible to grow rice in any area with poor soil. In this study, water -scarce areas such as Anuradhapura, Jaffna, Polonnaruwa, Vavuniya, Hambanthota & Urban areas like Colombo, Kandy, Galle, Negombo that will be most affected by water scarcity will be used to assess the feasibility applying circulating nutrient soluble hydroponic paddy systems in rooftop, while paying particular attention to water recycling and space constraints. The research stemmed from issues associated with conventional paddy farming, which is heavily reliant on vast quantities of water and cultivable land, unfit for urban and water scarce regions. To grow paddy plants, a circulating nutrient solution system was designed Growing medium (coco peat), Nutrient solution (Macronutrients: N, P, K/ Micronutrients: Fe, Mn, Zn, Cu, B and Mo), water & Albert's solution, Pipes & drip line, tank, pH meter & EC meter (optimal pH range 5.5-6.5and EC range 1.5-2.5mS/cm) and implemented, thus ensuring and prompt water usage. The objective of the experiment included measuring the growth of paddy plants, water consumption, and yield performance in a water is recycled three times a day, energy usage is minimal, while infrastructure costs and system maintenance are minimal & contrasting those results ,When installing a hydroponic system on a rooftop, a fairly sturdy roof is used and the outside of the system is painted white to control temperature and minimize the impact of solar radiation with the common method of cultivation. The study revealed that circulating nutrient soluble hydroponic paddy cultivation saves water recirculating nutrient solutions and sustains crop yield. (In addition, the system exhibited much promise for combination with rooftop farming by redevelopment of neglected areas.) Pest control is not a use of the soil. This is expected to result in a sustainable harvest, but further studies on the harvest are needed. Unused spaces in urban landscapes can be transformed into viable agricultural zones which in return will help increase food security in densely populated regions. This study emphasizes new advances in technology as saving water & space enabling strong agricultural production, this paradigm shift can solve challenges at the global level on food security and enhancing sustainability.

Keywords: *Hydroponic paddy cultivation, Nutrient-rich water solutions, Water scarcity, Urban agriculture, Water recycling, Sustainable rice production.*

Bioenergy and Biofuel Generation Technology

Production of Biomass Briquettes from Industrial Waste for Use as Fuel: Combustion Performance Analysis and Fuel Consumption Evaluation Using Simulation Software

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Abstract

Sugarcane bagasse is the major byproduct of the sugar industry, which is generated in large amounts around the sugar factories. While bagasse is used as a fuel source, the surplus bagasse is often stored in open areas, posing significant challenges to storage management. Waste crankcase oil (WCO) is a hazardous waste generated during vehicle engine oil changing procedures. This WCO is improperly disposed of, leading to environmental risk. The production of briquettes using bagasse and waste crankcase oil (WCO) offers a sustainable energy-generating method. The combined heat and power plant system was designed to simulate the combustion process of the briquettes. The EBSILON software was designed to generate a 125 MW electrical power and a 25 MW thermal power generation system. Briquettes were produced in 1:3 and 1:8 bagasse-to-WCO ratios. An automatic bomb calorimeter was used to measure the calorific value. The CHP simulation design consists of a fuel combustion system, a heat recovery steam generator system (HRSG), and a steam generator system. Finally, the electrical and CHP efficiency of the system was analyzed using two briquette fuel rations, providing insights into sustainable energy production. Based on the results, the CV values of the briquettes were recorded as 32034 kJ kg^{-1} and 34177 kJ kg^{-1} for 1:3 and 1:8 bagasse-to-WCO briquette ratio samples, respectively. The fuel mass flow rate required to produce a total of 150 MW in the CHP operation 1:3 bagasse-to-WCO briquettes ratio is recorded as 11.76 kg s^{-1}, whereas the 1:8 bagasse-to-WCO briquettes ratio decreased to 10.76 kg s^{-1}. In the 1:3 bagasse-to-WCO briquette ratio, the electrical energy efficiency of the system is 33.47%, and the CHP efficiency is 40.11%. In the 1:8 bagasse-to-WCO briquette ratio, the electrical efficiency improves slightly to 34.3%, and the CHP efficiency increases to 41.1%. Ultimately, this study demonstrates that biomass briquettes composed of WCO have a higher potential to be used as a combustible fuel with a higher calorific value of 34177 kJ kg^{-1}, 10.76 kg s^{-1} fuel feed rate of producing 150 MW power and achieving 40.11% CHP efficiency with the 1:8 bagasse to WCO ratio biomass briquette.

Keywords: *Bagasse, Briquette, Combined heat and power (CHP), EBSILON, Waste crankcase oil (WCO)*

Production of Biomass Briquettes from Industrial Waste for Fuel Applications: Environmental Impact Assessment Using Simulation Software

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Abstract

Industrial waste materials, such as spent wash (SW) and waste crankcase oil (WCO) combined with bagasse, show promise for sustainable energy through biomass briquettes. These briquettes are designed to utilize waste effectively, thus reducing reliance on non-renewable resources. This study examined the environmental impact of biomass briquette combustion, focusing on the dispensation of harmful flue gas emissions using analytical simulation software. Briquettes were made from mixing bagasse, SW, and WCO at the ratios of 1:3 and 1:8. An automatic bomb calorimeter was used to measure calorific values, and the combustion process was modelled in the EBSILON simulation software. The system is EBSILON-based and practically meant to generate 125 MW of electricity and 25 MW of heat power, proving its potential for improving efficiency while solving waste management challenges. Flue gas emissions in terms of CO_2, SO_2, NOx, O_2, and Temperature were studied to assess energy efficiencies and environmental impacts, and a conclusion was made regarding a comparison of the energy performance and emission profiles for each type of briquette. Based on studies, pure bagasse has a CV of 21,035 kJ/kg. The WCO-bagasse (1:8) briquette (34,177 kJ/kg) increases CV by 62%, while the SW-bagasse (1:8) briquette (13,810 kJ/kg) decreases it by 34%. Henceforth, the WCO-bagasse briquette provides more efficient operation. Based on the simulated CHP combustion operation with 150 MW total power output, lower CO_2 and SO_2 emissions were recorded in the WCO-bagasse briquette combusted system compared to the SW-bagasse system. The 1:3 and 1:8 ratios WCO-bagasse system emitted 862.02 and 884.45 mg/KWh of CO_2, while 4.17 to 4.34 mg/KWh of SO_2. These values were Within the acceptable European standard levels of 800-900 mg/KWh CO_2 emission and 1 to 5 mg/KWh SO_2 emission. However, the SW-bagasse 1:3 and 1:8 ratios systems emit around 1176.57 and 1178.86 mg/KWh of CO_2 and 25.26 and 29.18 mg/KWh of SO_2, which is out of the acceptable European standard levels. The energetic efficiency and environmental perspectives of the WCO-bagasse briquette provide better CHP operational conditions and can be utilized as a sustainable fuel.

Keywords: *Biomass Briquettes, Industrial Waste Utilization, Flue Gas Emission Analysis, Energy Efficiency, Environmental Impact Assessment*

Organic Fertilizer from Anaerobic Digestate: A Case Study of Slaughterhouse Waste Co-Digestion as a Sustainable Waste Management Solution

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Abstract

Organic digestate waste is a sustainable fertilizer derived from the anaerobic digestion of organic materials. This research evaluates the potential of digestate mixtures from slaughterhouse waste as organic fertilizers. In this study, five digestate mixture samples (S_1, S_2, S_3, S_4, and S_5,) and a control sample (S_0) were prepared. The compositions of the mixtures were S_1= 50% poultry + 30% chicken + 20% fish, S_2 = 40% beef + 30% chicken + 30% poultry, S_3 = 25% fish + 25% poultry + 25% chicken + 25% beef, S_4 = 50% fish + 50% cactus, S_5 = 50% poultry + 50% fish and S_0 = 100% soil. Field trials were conducted with six polybags using 50% soil and 50% of the digestate with eight chili seeds per polybag. Measurements of plant height, leaf size, stem diameter, and number of leaves were recorded every other day for three weeks. All the digestate mixtures were analyzed for Total Solids (TS), Volatile Solids (VS), and elemental composition (C, H, N, S, Cl, O) using CHNS and SEM analyzers. Muffle furnace and dry weight tests were used to determine the moisture and the Fixed Solid Content (FSC) respectively. Nutrient release and microbial activity were optimized using Aspen Plus software. S_5 sample was further analyzed for VS content which resulted in 97.05% and ultimate analysis resulted 40%, 35%, 4%, 1.75% of C, O, N and S respectively. Aspen optimization indicated the S_1 sample was optimal for nutrient release, and there was significant improvement in microbial activity. The study demonstrates that carefully balanced digestate mixtures can significantly improve plant growth and nutrient availability. Aspen optimization can help in identification of the best solutions related to the conversion of digestate waste into resources by developing an optimal profile through input biomass datasets.

Keywords: *Aspen Simulation, CN ratio, Digestate, Organic fertilizer, Sustainable Agriculture*

Bioremediation of Textile Industry Wastewater by *Nostoc* sp. and Analysis of its Fatty Acid Profile for Biodiesel Production

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Abstract

This study explores an integrated approach to bioremediate textile industry wastewater (TWW) using *Nostoc* sp., followed by biodiesel production from TWW-grown cyanobacterial biomass. Initially, TWW was collected from a leading textile company in the Colombo district, Sri Lanka, and initial physicochemical parameters were measured. A 10% (v/v) homogenous inoculum of *Nostoc* sp. was inoculated into transparent glass tanks with a total volume of 20 L of TWW under greenhouse conditions providing continuous aeration and a 12:12 light: dark photoperiod. The growth of *Nostoc* sp. and TWW decolorization were evaluated spectrophotometrically over a period of 4 weeks. After 4 weeks, significant growth performance and TWW decolorization were observed, indicating its potential for sustainable TWW treatment. Pollutant removal was assessed via the reduction of chemical oxygen demand (COD), giving a significant reduction of 96.48 ± 0.37%. In terms of nutrient removal, ammoniacal nitrogen, nitrate, and phosphate removal were assessed and they were recorded as 76.28 ± 0.79%, 69 ± 1.07%, and 81.14 ± 0.73%, respectively. The wastewater-grown biomass was harvested via filtration and oven-dried at 55˚C to obtain its dry powder. The lipids of *Nostoc* sp. were extracted in a soxhlet apparatus using *n*-hexane as the extraction solvent and a total lipid content of 21.5% (w/w) was obtained. Lipids were converted to their fatty acid methyl esters (FAMEs)/biodiesel via a transesterification reaction. The transesterified lipids were analyzed via Agilent 7890B GC-FID system. The major FAMEs identified were palmitic acid (C16:0), oleic acid [C18:1 cis (n9)], stearic acid (C18:0), cis-10-pentadecanoic acid (C15:1), lauric acid (C12:0), and myristic acid (C14:0), with percentages of 45.92%, 24.77%, 8.82%, 8.65%, 6.66% and 5.19%, respectively, indicating a well-balanced saturated and unsaturated FAME composition for biodiesel production. Thus, this integrated approach not only offers a sustainable solution for TWW remediation but also simultaneously provides a potential feedstock for biodiesel production.

Keywords: *Biodiesel, Bioremediation, Lipid content, Nostoc sp., Textile wastewater*

An Innovative Approach for Bioenergy Production from Slaughterhouse Waste: Enhancing the C: N Ratio for Maximized Biogas Yield

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Abstract

Slaughterhouse waste consists of higher amount of protein content which contributes to the production of higher volume of biogas due to the activity of anerobic bacterial communities. In fact, the findings of this work hold significant potential impact on optimization of renewable energy technologies as well as waste management systems. The main conflict with the substrate for energy production is producing the foam because of higher N content. It was a limitation to impact for calorific value in the biogas and cause to be harmful for health of environment. The method of Kjeldal and SEM analysis was used to determine the C:N ratio of each substrate. The waste C:N ratio was calculated to be 10:1 and this was further optimized to an optimal C:N ratio of 16:1 in the presence of bagasse. The substrate consisted of poultry manure, beef waste, chicken waste, cactus, and fish waste, while anaerobic sludge served as the inoculum. The Inoculum was also impacted to change the value of C:N ratio. There were five batch reactors where the digestion used to happen. The results showed that the adjustable C:N ratio greatly reduced ammonia generation and, as a consequence, biogas yield. The substrate with a C:N ratio 30:1 gave the highest CH_4 (76%) production in the reactor that consist of 50%:20%: 30% of poultry manure: fish waste: chicken waste. The poultry manure was identified as the carbon rich substrate which was scaled up by adding bagasse. Future research should focus on investigating the material behavior and usage of the nano technology to enhance the digestibility of the carbon content of the initial material which is key for achieving optimal bioenergy production from slaughterhouse waste. This optimized substrate composition ratio and C:N ratio provided an optimal increase in biogas production offering a potential environmentally friendly alternatives to fossil fuels.

Keywords: *Scanning Elemental Microscopy, Anaerobic Digestion, C: N Ratio Optimization, Bioenergy Generation, Ammonia Removal*

Anaerobic Reactor Design for Industrial Waste Management: An Overall Prospective with Pressure Control to Enhance System Reliability Using CAD Software

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Abstract

Industrial waste management is problematic because the organic streams are complex and variable, necessitating appropriate treatment methods. Anaerobic digestion is one of the most extensively used biochemical processes in converting organic waste into biogas and a nutrient-rich digestate without oxygen. In practice, however, process instabilities, such as fluctuating OLR, inefficient VS degradation, and risks of over-pressurization, commonly affect performance and system reliability. The combination of aspen plus process modeling, CFD simulations and real-time monitoring for optimizing methane yield and system efficiency sets this research apart from traditional emphasis basis studies. This research encompasses the design, modeling, and optimization of a 7.2 m^3 hybrid anaerobic reactor fitted with an automated pressure control system to enhance process stability and improve biogas yield. CAD modeling was performed in SolidWorks using a parametric approach. From CFD simulations, fluid flow pattern, turbulence characteristics, mixing efficiency, and stability of pressure were analyzed at different OLRs. The reactor working volume for this design was 5.4 m^3 at 75%, and the gas storage buffer was 1.8 m^3 at 25% to damp fluctuation of biogas. Some of the safety features that were installed consisted of a pressure relief valve, a biogas flow meter, and backflow preventers to avoid over-pressurization. The system treats 60 kg of organic waste per day, diluted to 180 L/day, using an HRT of 30 days for adequate microbial degradation. Organic fraction adds 12 kg TS/d (9.6 kg VS/d), yielding a biogas output of 6.4 m^3/d with a methane content of 60% (3.84 m^3 CH_4/day). Indeed, this reactor reached 50% VS degradation efficiency that improved microbial activity and optimized the methanogenesis pathways. Again, it showed that much better could be the economy-of-scale savings of waste management with a large GHG emission reduction and energy recovery rise at an industrial plant that treated 3 tons per day of organic wastes. In brief, it emphasizes how full-scale plants would be benefited furthering anaerobic digestion by real-time monitoring and automated enhancement, energy hybrid systems to be created to make anaerobic digestion feasible. Thus, further study of kinetic modeling and microbial analysis by adaptive control systems is underway.

Keywords: *Anaerobic Digestion, Computer Aided Devices, Fluid Dynamics, Organic Loading Rate, Pressure Relief valve*

Evaluation of NH_3 Production in Anaerobic Reaction: The Importance of Reducing Ammonia As a waste for Energy Value and Efficiency Determination Using Aspen Plus

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Abstract

Ammonia-N accumulation in AD systems is considered a big challenge since it inhibits methanogenic activity, reduces the yield of CH_4, and increases the purification cost, consequently impacting the efficiency of biogas production as a whole. This work integrates experimental analysis and thermodynamic modeling using Aspen Plus with the aim of quantifying NH_3 generation and its impact on energy yield in biogas, besides assessing mitigation strategies that could be effective. In the present study, five substrates were considered: poultry manure, fish waste, chicken offal, beef waste, and Opuntia ficus-indica. These substrates were considered in various combinations to obtain the best C:N ratio that would minimize ammonia toxicity. Experimental results indicated that a C:N ratio of 16:1 and a PH range between 6.8 and 7.8 minimized NH_3 production from 1,450 mg/L to 580 mg/L. By reducing the PH value, CH_4 yield was increased by 23.5%, and methane content in biogas increased from 52.4% to 64.8%. Moreover, VS degradation was followed, and the efficiency of substrate conversion increased from 62% to 78% under the optimal conditions. Aspen Plus was used to construct a T-x-y phase diagram for the H_2O-NH_3 system which is useful for identifying ammonia volatilization thresholds. Above 55°C and NH_3 concentrations higher than 1,200 mg/L, the ammonia removal efficiency via stripping was 92%, reducing the toxicity effects considerably. In this context, the simulation results indicated that ammonia remains mostly in liquid form below 35°C, but volatilization increases significantly with rising temperature. Most research works focus solely on ammonia toxicity reduction, whereas this research quantifies the impact of NH_3 reduction on overall energy efficiency. Future work will be carried out by incorporating ammonia-stripping technologies into biogas reactors, including gas-permeable membranes and chemical absorption. Further improvement will be achieved by the development of machine-learning-assisted simulation models for real-time process optimization. It points out that effective NH_3 control strategies will be required for increasing the NCV of biogas to 22.1 MJ/m^3, ensuring process stability, and increasing the economic viability of sustainable bioenergy production.

Keywords: *Ammonia inhibition, Aspen Plus, Simulation, Thermodynamic, Stripping Technologies*

Analysis of Phase Equilibrium and Molar Fraction Behavior in Anaerobic Digestion with Acid Pre-Treated Substrates Using Aspen Plus Simulation

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Abstract

Anaerobic digestion is a renewable energy technology that converts organic waste into a biogas and a digestate. Phase equilibrium behavior for key components of CH_4, CO_2, H_2O, and NH_3 is required for process optimization. Aspen Plus simulation gives an elaborative insight into the thermodynamic interactions of such components. The present work has used Aspen Plus to build up T-x-y diagrams and discuss the liquid-vapor equilibrium behavior, combining results with experimental biogas production. Accordingly, the model results showed a decrease in the methane solubility by 12.4% as the pressure increased from 1 to 5 atm and by 8.7% with temperature increase from 35 to 55°C. under similar conditions; a 14.3% reduction in the CO_2 solubility influences the CH_4/CO_2 equilibrium. Phase diagrams reveal the volatility of ammonia, and the desorption of NH_3 rises by 17.6% when the temperature increases from 35°C to 50°C, while water vaporizes at 9.8% in the same range, both providing the possibility for PH variations in the reactor**.** Experimental validation with a 50:50 poultry manure-cactus mixture gave the highest methane yield of 247.8 ml CH_4/g VS, while the composition of biogas was 62.4% CH_4, 34.6% CO_2, 2.1% NH_3, and 0.9% H_2S. The reduction of volatile solids was 34.21 g while TAN varied between 2200-2650 mg/l, thus confirming ammonia inhibition thresholds. Therefore, changing the C/N ratio from an unfavorable 18.7 to an optimal ratio of 22.5 at a maintained pH of 7.28 remarkably improved the process stability along with methane production as evidenced by simulations. Additionally, thermodynamically stable biogas could also be obtained since T-x-y diagrams revealed the increase of partial pressure of CH_4 at 0.42 atm to 0.57 atm between 35-50°C thus favoring CH_4 enrichments within the gas-phase. Future studies ought to be aimed at real-time monitoring of the phase equilibrium parameters and the development of advanced techniques for pretreatment to make substrates more bioavailable. Upscaling with Aspen Plus for industrial-scale anaerobic digestion systems promises efficient methane production along with better energy recovery.

Keywords: *ASPEN Plus, Anaerobic Digestion, Pretreatment, Simulation, Thermodynamical*

Coagulation for Pre-Treatment of Dairy Wastewater and Energy Recovery from Sludge

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Abstract

Food industries generate a large amount of wastewater. Among them, dairy industries contribute a significant portion. Dairy wastewater treatment is highly challenging due to the discharge volumes and organic pollutant load. Additionally, the high organic load results in elevated Chemical Oxygen Demand (COD) levels. To reduce COD, various treatment technologies are employed, with coagulation being one of the primary methods. Different coagulants are used for this purpose in this research. Commonly used inorganic coagulants, $Fe_2(SO_4)_3$ and $Al_2(SO_4)_3$, an organic coagulant of Hanfloc (HF) were compared to evaluate their COD removal efficiencies. Real wastewater was obtained from a dairy treatment plant, with an initial COD of 3040 mg/L. The milk proteins and lipids in dairy wastewater likely contribute to the high COD. Different coagulant concentrations were tested, with 1000 ppm of $Fe_2(SO_4)_3$ and 800 ppm of $Al_2(SO_4)_3$ identified as the optimal doses for COD removal. However, the polymer coagulant of HF optimum dose was only 100 ppm. The optimum COD removal efficiencies achieved were 73% for HF, 59% for $Fe_2(SO_4)_3$, and 62% for $Al_2(SO_4)_3$. The sludge accumulation rate was lowest for the polymer coagulant HF, with less than half the sludge volume compared to the two inorganic coagulants. Sludge characterization using FTIR and TGA revealed peaks corresponding to lipids in all three sludge samples, with the highest peak intensities observed for the polymer coagulant. Based on these findings, the polymer coagulant HF is recommended for dairy wastewater treatment. Additionally, the lipid-rich sludge produced is suggested as a potential feedstock for biodiesel production.

Keywords: *Biodiesel, Chemical oxygen demand, Coagulants, Dairy, Wastewater*

Utilization of Ceylon Satinwood Latex (Burutha) And Glycerol as Alternative Binders in Biomass Briquette Manufacturing

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Abstract

Briquettes made of biomass have become a viable, economical, and environmentally responsible way to address the world's energy crisis. Issues with food safety and the environment have risen because of the manufacturing of briquettes using conventional synthetic and food-based binders. This study aims to assess Ceylon Satinwood (Burutha) resin a locally available natural resin and glycerol, a byproduct of biodiesel manufacturing, as sustainable alternative binders by contrasting their performance with that of the widely used binder, starch. As feedstock, the study used a variety of compositions of water, binder, and biomass wastes, such as sawdust, paddy husk, and paddy husk biochar. A hydraulic briquetting machine was used to manufacture cylindrical briquettes, and a bomb calorimeter was used to measure their calorific values and a universal strength testing machine to evaluate their mechanical strength. According to the findings, briquettes made of glycerol produced the most energy (24.29 MJ/kg), followed by Ceylon Satinwood resin (20.51 MJ/kg) and starch (17.55 MJ/kg). Ceylon Satinwood resin-based briquettes demonstrated remarkable mechanical strength, especially in sawdust and char combinations, with average stress values of 0.5 MPa. The commercial standard, starch-based briquettes, performed best with rice husk, achieving a stress value of 0.4 MPa, which indicates moderate mechanical strength. When compared with all biomass types, glycerol's mechanical strength was moderate despite its exceptional calorific value. Ceylon Satinwood resin offers the best structural integrity, especially in sawdust and char-based briquettes, while glycerol is the best binder for optimizing energy production. These results highlight how natural binders can improve biomass durability and energy efficiency that would enhance storage, transportation and handling in Briquette industries.

Keywords: *Biomass Briquettes, Natural Binders, Ceylon Satinwood Resin, Glycerol, Mechanical strength*

Sustainable Bioenergy Production Through the Pyrolysis of *Mimosa pigra* (Yodha Nidikumba): A Solution for Invasive Species Management

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Abstract

Mimosa pigra, is included among the top 100 invasive plant species in the world and is causing severe ecological and economic damage to the wetlands and agricultural areas of Sri Lanka. Its spread causes significant impact on biodiversity, decreases the productivity of the lands, and increases management costs. Traditional control measures often depend on non-ecofriendly chemicals and cause environmental degradation, involving high expenses. This study will determine the potential of thermal decomposition of Mimosa biomass through pyrolysis as an alternative approach in managing *Mimosa pigra*. Pyrolysis will help to control the invasive species and is a producer of value-added products, such as bio-oil, biochar, and syngas, contributing to renewable energy development. The collection of *Mimosa pigra* biomass from the field at the Samanalawewa area was followed by pretreatment specifically cleaning, drying at 105°C for 12 hours, and finally the size reduction. The biomass was pyrolyzed at 400–500°C for 1 hour and 30 minutes in a lab-scale fixed-bed reactor. The resulting biochar, bio-oil, and syngas were collected and analyzed with a bomb calorimeter, moisture analyzer, syngas analyzer, and closed cup flash point analyzer for the determination of energy content, composition, and suitability of the produced bio-oil and syngas as renewable energy sources. The results show that the calorific value of *Mimosa pigra* biomass is 30.187 MJ/kg with a moisture content of 5.928%, hence it renders to be an effective bioenergy feedstock. The flash point of the bio-oil produced was 34.5°C. GC-MS analysis shows poly-aromatic hydrocarbons present in the bio-oil, so it can also be used as renewable fuel and chemical synthesis. The thermal decomposition of *Mimosa pigra* through pyrolysis offers a promising, sustainable solution for invasive species management and renewable energy production. This approach supports climate change mitigation, promotes sustainable bioenergy development, and reduces dependency on non-renewable energy sources. Optimizing pyrolysis conditions and exploring applications of biochar in soil amendments and wastewater treatment are important focuses for future research to maximize the environmental benefits.

Keywords: *Mimosa pigra, Pyrolysis, Bio-oil, Biochar, Renewable Energy, GCMS*

Production of Biodiesel from Waste Poultry Fat: A Case Study in Sabaragamuwa University of Sri Lanka

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Abstract

The need for renewable alternatives to fossil fuels has increased due to the increasing demand for sustainable and renewable energy. The present study is on biodiesel production using waste poultry fat as a case study that was carried out in Sabaragamuwa University of Sri Lanka. The utilization of waste poultry fat will contribute not only to the lessening of environmental burdens due to poor waste disposal but also to support concepts of a circular economy transforming waste into useful energy. Waste poultry fat was obtained from local restaurants in Belihuloya area followed by washing and cleaning to remove debris. Cleaned fat was heated, and oil was recovered at a rate of 275 ml from 3 kg of waste poultry fat. Free fatty acid content was determined by titrating the sample with potassium hydroxide in the presence of phenolphthalein indicator. Biodiesel production Transesterification was carried out in which pre-treated poultry fat was allowed to react with methanol in the presence of a catalyst, sodium hydroxide for one hour at a temperature of 55–60°C. The produced biodiesel was purified by hot water washing followed by centrifugation for removal of glycerol and other impurities. The results showed a FFA level of 1.12% and biodiesel yield of 81.81% and glycerin content of 18.36%. Major fuel properties like calorific value were 40.457 MJ/kg with a flash point of 126.5°C, which proves that the biodiesel has very high energy content and is safe for handling. The fuel properties were comparable to commercial biodiesel, which indicates that waste poultry fat can be an effective feedstock to produce biodiesel. Biodiesel produced from waste poultry represents a very promising sustainable, cost-effective, and environmentally friendly alternative to fossil fuels.

Keywords: *Biodiesel Production, Waste Poultry Fat, Renewable Energy, Transesterification, Sustainable Fuel*

Sustainable Bioenergy: Enhancing Biomass Briquettes through the Combination of Rice Waste & Gliricidia

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Abstract
The transition towards renewable energy has intensified the demand for sustainable biofuel technologies. Traditional biomass briquetting often relies on single raw materials, which limit briquette performance. Combining different biomass materials addresses this limitation, enhancing overall briquette performance. This study investigates the optimal combination of *Gliricidia sepium* (G), rice straw (RS), and rice husk (RH) for biomass briquetting, leveraging locally available resources to promote sustainability. Rice straw acts as a natural binder, while rice husk provides structural integrity and combustion characteristics and Gliricidia enhances calorific value. Five formulations were tested: G30%: RS53%: RH17%, G40%: RS45%: RH15%, G50%: RS38%: RH12%, G60%: RS30%: RH10%, and G70%: RS23%: RH7%. Due to moisture variations, formulations beyond 70% Gliricidia were not tested. Raw materials were processed by debarking Gliricidia, reducing size (2–4 cm), drying, and mixing. Cylindrical briquettes were manufactured using a mechanical briquetting machine (45 mm die size) and analyzed for calorific value, ash content, volatile matter, fixed carbon, moisture content, and bulk density. Results indicate that increasing Gliricidia proportion significantly enhances calorific value and volatile content, while reducing ash content. The blend G 70%: RS 23%: RH 7% yielded the highest energy output (4188.2 Kcal/kg) and lowest ash content (6.32%). Statistical analysis confirmed a significant impact ($p < 0.05$) of biomass composition on briquette properties. A strong negative correlation ($r = -0.98$) was observed between ash content and calorific value, while regression analysis ($R^2 = 0.94$) identified moisture content, volatile matter, and ash content as key predictors of fuel efficiency. These results demonstrate that Gliricidia & Rice waste enriched biomass briquettes are a feasible, sustainable, and cost-effective biofuel solution. The work contributes to biomass fuel optimization, industrial fuel use, and rural energy supply. Future research should focus on scaling production, emission studies, and thermochemical processes like torrefaction to enhance energy density and stability.

Keywords: *Bioenergy, Biomass briquettes, Biofuel technology*

Optimization of Free Fatty Acid Reduction in Sludge Palm Oil Through Base Neutralization and Esterification for Enhanced Biodiesel Production

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Abstract

The global oil industry is increasingly turning to biodiesel as an alternative fuel due to rising fossil fuel prices and environmental concerns. Biodiesel is considered a superior alternative to petroleum diesel because it is environmentally friendly while providing the same functional properties. However, the palm oil extraction process generates waste, such as Sludge Palm Oil (SPO), which contains high levels of Free Fatty Acids (FFA), making it unsuitable for biodiesel production. This study aims to reduce FFA content in SPO to enhance biodiesel yield and evaluate its fuel properties. The study used base neutralization and esterification processes, followed by transesterification. In the neutralization process, sodium hydroxide (NaOH) concentrations (0.1%–0.5%) were added to SPO heated to 60°C. After treatment, FFA content was measured, and the optimal FFA reduction was achieved with 0.5% NaOH for 120 minutes, reducing FFA from 10.09% to 3.48%. However, higher NaOH concentrations resulted in significant oil losses, with the best balance found at 0.3% NaOH for 120 minutes, reducing FFA to 3.86% with a retention of 71.44%. For esterification, sulfuric acid catalyzed reactions with varying methanol-to-oil ratios were tested. The optimal reduction in FFA (2.26%) occurred at a 6:1 methanol-to-oil ratio. The transesterification process showed that biodiesel yield increased with higher methanol ratios, reaching 71.25% at an 8:1 ratio, with 7:1 being the most economically efficient. The produced biodiesel met ASTM standards, with a calorific value of 40.01 MJ/kg, a flash point of 180.5°C, and a kinematic viscosity of 4.44 mm^2/s. The study concluded that esterification significantly reduces FFA, making SPO a viable second-generation biodiesel feedstock, and optimizing the methanol-to-oil ratio enhances both yield and quality.

Keywords: *Sludge palm oil, Free fatty acid reduction, Esterification, Transesterification, Methanol-to-oil ratio*

Feasibility Study of Producing Charcoal Briquettes from Coconut Shell Charcoal and Sawdust Using Eco-Friendly Natural Binders for Sustainable Energy Solutions

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Abstract

Energy consumption continues to rise with increasing population and economic development, driving the demand for sustainable and eco-friendly energy sources. Biomass briquettes, made from organic waste materials, have gained attention as an alternative to conventional fuels. Various adhesives are used in briquette production, but the potential of non-edible adhesives remains largely unexplored. This study evaluates the feasibility of producing briquettes from waste coconut shell charcoal and cinnamon waste sawdust using eco-friendly adhesives. The aim is to determine the optimal adhesive composition to improve briquette characteristics. The briquette fabrication process includes biomass carbonization, crushing, mixing, pressing, and drying. Three adhesive formulations were tested, incorporating 5%, 7.5%, and 10% of cassava peel starch, Habarala starch, and pine resin, based on the total weight of coconut shell charcoal and cinnamon sawdust. These adhesives were mixed with three different ratios of coconut shell charcoal to cinnamon sawdust: 100:0, 90:10, and 80:20. The mixtures were compressed using a hydraulic press with a 30-second dwelling time and sun-dried for 12 days. The briquettes had a cubical shape of 35 mm, ensuring uniformity. Key properties such as calorific value, density, compressive strength, proximate analysis, and shatter resistance index were assessed to determine the best formulation. The calorific values ranged from 6226 Cal/g to 7591 Cal/g, meeting the Indonesian National Standard (SNI 01-6235-2000) of ≥5000 Cal/g. The briquette density ranged from 0.8332 g/cm³ to 1.1356 g/cm³. Habarala and cassava peel starch showed higher bonding strength, with a shatter resistance index of 98.03% to 99.49%, meeting the SNI 8675 (2018) quality standard of 98%. Cassava peel starch demonstrated the best performance for durability and energy release, with higher calorific value and density. Habarala starch also improved durability, while pine resin, though high in calorific value, reduced compressive strength and shatter resistance. This research highlights the potential of non-edible adhesives in producing high-quality, eco-friendly biomass briquettes for industrial and commercial use.

Keywords: *Eco-friendly Binders, Biomass briquettes, Coconut shell charcoal, Energy sustainability, Pyrolysis.*

The Role of Invasive Plants in Biomass Energy Production: A Case Study of *Pinus caribaea* in Sabaragamuwa Province of Sri Lanka

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Abstract

The global energy crisis, driven by the depletion of traditional energy sources, has intensified the need for renewable energy. Fossil fuels, which constitute the majority of the world's energy supply, are a major cause of environmental degradation and global warming. In response, there is increasing interest in renewable energy to reduce carbon emissions and mitigate global warming. At the same time, invasive species like *Pinus caribaea* are spreading rapidly in regions such as Balangoda, Sri Lanka, where they disrupt ecosystems by displacing native plants, reducing biodiversity, and promoting fires. *Pinus caribaea* has already overtaken more than 18,000 hectares in Sri Lanka, presenting both a biological challenge and an opportunity for bioenergy production. This study explores the potential of *Pinus caribaea* biomass for combustion and pyrolysis as a sustainable energy source while addressing its invasive spread. The study compares *Pinus caribaea* with *Gliricidia sepium*, a widely used fuelwood species in Sri Lanka, to evaluate its energy viability. Biomass samples of *Pinus* were collected from Belihuloya, Sri Lanka, and their drying profile was also assessed for biomass utilization. Chopped biomass samples underwent pyrolysis in a lab-scale reactor at 400°C for 1 hour to obtain pyrolysis oil. The calorific values of both wood and pyrolysis oil were measured using a bomb calorimeter, and the viscosity and density of pyrolysis oil were analyzed. The study found that *Pinus caribaea* has a higher wood density (0.89 g/cm³) than *Gliricidia sepium* (0.74 g/cm³), indicating a higher energy yield per unit volume. The calorific values of *Pinus* wood (22.87 MJ/kg) and pyrolysis oil (36.94 MJ/kg) are significantly higher than *Gliricidia* (15.67 MJ/kg and 27.34 MJ/kg, respectively), demonstrating its strong energy potential. Additionally, *Pinus* has a lower moisture content (23.86%) and dries faster, making it a more efficient fuel source. These results suggest that *Pinus caribaea* can serve as an excellent biomass energy source, helping control its spread and contribute to Sri Lanka's renewable energy sector.

Keywords: *Pinus caribaea, Biomass energy, Invasive species, Energy properties, Renewable energy*

Pyrolytic Conversion of Plastic Waste into Sustainable Energy: An Investigation of Bio-Oil, Syngas, And Biochar Production at Sabaragamuwa University of Sri Lanka

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Abstract

Plastic waste is a significant environmental issue due to its non-biodegradable nature and increasing accumulation in landfills, oceans, and ecosystems. This challenge is particularly pronounced in developing countries like Sri Lanka, where waste management is a growing concern. This study aims to quantify plastic waste generation at the Sabaragamuwa University of Sri Lanka and explore sustainable methods to convert this waste into valuable energy sources. Pyrolysis, a thermochemical process, was conducted at 400°C for 1 hour to convert plastic waste into bio-oil, syngas, and biochar, with properties comparable to conventional fossil fuels. Plastic waste was collected from various university locations, cut into 2 cm pieces, and subjected to pyrolysis in a small-scale batch reactor. The study focused on understanding the relationship between the amount of raw plastic material and the resulting bio-oil yield. Experimental trials were conducted with PVC, polyethylene, and PET plastics. For polyethylene, 2.745 g of raw material produced 250 ml of bio-oil with a flash point of 28.5°C, a calorific value (CV) of 47.27 MJ/kg, and a density of 0.7955 g/cm³. The syngas produced had a calorific value of 3.42 MJ/m³ (14.33 MJ/kg). PVC pyrolysis, using 1.245 kg of raw material, yielded 110 ml of bio-oil with a flash point of 63°C, a CV of 17.69 MJ/kg, and a density of 1.015 g/cm³. The syngas from PVC had a calorific value of 3.49 MJ/m³ (14.61 MJ/kg). PET, however, failed to produce bio-oil due to heating issues, resulting in a waxy material. The study estimated annual plastic waste generation at the university, leading to the production of approximately 6,643 liters of bio-oil from polyethylene and 1,615 liters from PVC. With an average price of furnace oil at LKR 207.00 per liter, the total annual value of the bio-oil produced is approximately LKR 1,710,486. These findings highlight the potential of pyrolysis as a viable technology for converting plastic waste into sustainable energy while contributing to waste management and energy recovery.

Keywords: *Plastic waste, Pyrolysis, Sustainable Plastic Waste Management, Pyrolysis oil, Syngas, Biochar*

Biomass Utilization of Pinto Peanut (*Arachis pintoi*) for Sustainable Energy: Feasibility of Biodiesel, Bio-Oil, Biochar, and Briquette Production

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Abstract

Energy use is rising, leading to challenges such as the depletion of traditional sources and environmental harm from fossil fuels. This has increased the demand for sustainable and renewable energy sources. This study evaluates the effectiveness of biomass-based energy production for supporting sustainability, focusing on the potential of pinto peanut (*Arachis pintoi*) a common cover crop in Sri Lankan tea plantations as a bioenergy source. The seeds and shells of pinto peanut were used to produce biodiesel, bio-oil, biochar, and briquettes. The seeds were collected from the Sabaragamuwa University of Sri Lanka's agricultural farm, and oil was extracted using a mechanical method, yielding approximately 600 mL of oil per kg of seeds. The extracted oil's calorific value and free fatty acid (FFA) content were analyzed. Biodiesel was produced through the transesterification process, using 6 g of NaOH, 150 mL of ethanol, and 10 drops of phenolphthalein. After transesterification, the biodiesel was purified by washing with warm water to remove impurities. Additionally, the shells were used in pyrolysis to produce bio-oil, syngas, and biochar in a lab-scale reactor at 400°C. The shells were also used to produce briquettes by mixing them with paper waste collected from the university. Six different raw material ratios were tested for briquette production. The study assessed key properties such as calorific value, density, and compressive strength. The calorific value of the raw oil was 39.623 MJ/kg, and the FFA content was 0.616%. The biodiesel produced had a calorific value of 40.541 MJ/kg, a density of 0.86348 g/cm³, and a flash point of 157.5°C. The pyrolysis of peanut shells produced 18 mL of bio-oil with a calorific value of 46.435 MJ/kg, 38.98% biochar, and syngas with a calorific value of 1,058.6 kcal/m³. Briquettes made from peanut shells and paper/cardboard waste had calorific values ranging from 12.942 to 17.290 MJ/kg, with compressive strength ranging from 101.93 kN to 102.25 kN. These results demonstrate that pinto peanut can be a viable renewable energy source for sustainable biofuels.

Keywords: *Renewable energy, Pinto peanut, Biodiesel production, Pyrolysis bio-oil, Biomass briquettes*

Sustainable Waste Disposal and Energy Generation from Scrap Rubber Tracks Through Pyrolysis Technology

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Abstract

This research develops an environmentally friendly and sustainable waste disposal process for non-degradable rubber tracks that often end up as waste. Unlike conventional rubber tires, rubber tracks have a unique composition requiring specific disposal methods. Improper disposal leads to environmental pollution and resource wastage. This study investigates the feasibility of converting scrap rubber tracks into valuable pyrolysis products, including pyrolysis oil, syngas, and biochar, using pyrolysis technology. Discarded rubber track waste was collected from an industrial facility in Sri Lanka, and a laboratory-scale batch-type pyrolysis reactor was designed to maintain 400°C and a residence time of 1 hour. The experiments were conducted at the Bioenergy Laboratory, Faculty of Technology, Sabaragamuwa University of Sri Lanka. The study began by analyzing the thermal decomposition behavior of the rubber tracks and proceeded to quantify the three main pyrolysis products. The mass balance of the pyrolysis oil, syngas, and biochar yielded average product distributions of 30%, 34%, and 36%, respectively. The pyrolysis oil was tested for density, calorific value, flash point, viscosity, boiling point, and pH. The results showed a density of 0.8671 g/cm³ at 30°C and 0.8588 g/cm³ at 40°C, a calorific value of 45.862 MJ/kg, a flash point of 33.5°C, a viscosity of 1.3744 cP at 30°C, and 1.1917 cP at 40°C, a boiling point of 140°C, and a pH of 8.5. The syngas composition included 2.39% CO, 5.77% CO_2, 20.37% CH_4, 36.66% H_2, 0.53% O_2, and 10% CnHm, with a calorific value of 4322.2 kCal/m³. Biochar was found suitable for soil improvement and carbon sequestration. The results confirm that rubber track waste can be effectively converted into energy products through pyrolysis, providing a sustainable alternative to disposal. Based on approximately 5 tons of industrial waste generated monthly, the process can produce 1,500 liters of bio-oil and 1,700 kilograms of syngas per month. The study confirms that pyrolysis offers a sustainable solution for rubber track waste disposal and presents a valuable energy recovery option. Future research will focus on optimizing the process and assessing the feasibility of scaling it for industrial use.

Keywords: *Scrap rubber Track, Pyrolysis, Pyrolysis oil, Syngas, Flash Point, Thermal decomposition*

Biochar-Enriched Organic Fertilizers from Sugar Industry Waste: A Sustainable Approach to Soil Fertility and Crop Growth

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Abstract

Sri Lanka's sugar industry generates substantial organic waste, including bagasse, ash, spent wash, and cane tops, much of which is underutilized or improperly discarded, leading to environmental challenges. The country also faces soil degradation, fertilizer shortages, and declining agricultural productivity, which highlight the need for sustainable alternatives to conventional fertilizers. This study explores the production and effectiveness of paddy husk biochar-enriched organic fertilizers derived from sugar industry waste and their impact on corn plant growth over a 45-day period. Six formulations of sugar industry waste-based fertilizers were developed to evaluate the impact of raw material composition: T1 (100% bagasse), T2 (50% bagasse + 50% ash), T3 (50% bagasse + 25% ash + 25% spent wash), T4 (50% bagasse + 50% cane top), T5 (50% bagasse + 16% ash + 16% spent wash + 16% cane top), and T6 (50% bagasse + 50% spent wash). Each formulation was tested under three biochar application rates 0% (T1-T6) , 10%(T7-T12) , 20% (T13-T18) with each treatment group replicated three times. Additionally, each replicate included a commercial organic fertilizer control (T19) and unfertilized soil control (T20), providing a basis for comparison. Sixty polybags (20x3) containing 50% soil and 50% organic fertilizer were used for a uniform growing medium, and the experiments were conducted under controlled temperature and humidity conditions to optimize plant growth. Plant growth was assessed based on height, girth, number of leaves, and dry matter content. Statistical analysis with repeated measures ANOVA in SPSS 26 revealed that T17 exhibited the highest growth rates, outperforming all other treatments and even surpassing the controls. T1, T2, and T6 showed the lowest growth rates. Biochar incorporation significantly improved plant growth, with the 20% biochar application proving the most effective. These findings emphasize the potential of reusing sugar industry waste to create biochar-based fertilizers that improve soil fertility and increase agricultural productivity. This approach supports Sri Lanka's sustainable agriculture initiatives and offers a solution for sustainable waste management, contributing to long-term agricultural development.

Keywords: *Biochar, Organic fertilizer, Sugar industry waste, Corn plants, ANOVA, Sustainable agriculture*

Preparation, characterization, and cationic dye removal study of biochar prepared from king coconut husk

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Abstract

Water pollution due to dye contamination is a significant environmental issue, requiring sustainable and cost-effective water treatment solutions. This study investigates the potential of utilizing agricultural wastes such as King Coconut Husk (KCH) to produce Biochar (BC) for dye adsorption to mitigate aquatic pollution. The KCH was pyrolyzed under an argon gas environment at four temperatures (300°C, 400°C, 500°C, and 600°C) to obtain BC. This study focuses on the selection of optimal temperature and other physicochemical properties to enhance the adsorption efficiency. Brunauer-Emmett-Teller (BET) surface area analysis, X-ray Diffraction (XRD), Raman spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), and Scanning Electron Microscopy (SEM) were used to characterize the BC in order to determine its chemical and structural characteristics. The biochar produced at 500^{o} C exhibited the highest surface area and well-developed porous morphology, making it the most suitable for dye removal. The dye adsorption study investigated the effect of several process variables on the adsorption process, including adsorbent dosage, initial dye concentration, solution pH, contact time, solution temperature, salt dosage. The maximum adsorption efficiency was achieved under optimal conditions of 50°C solution temperature and 90 minutes of reaction time. The adsorption efficiency could be further improved by increasing the pH, adsorbent amount and salt dosage. Isothermal studies of BC indicated a better fit with both Langmuir (R^2=0.9676) and Freundlich (R^2=0.9856/n=1.45) models, suggesting monolayer and multilayer adsorption and physisorption with weak chemisorption. the maximum adsorption capacity was determined as 59.53mgg^{-1}, confirming better adsorption performance compared to conventional biochars like rice husk BC (50.27mgg^{-1}). The results indicate the potential use of KCH-derived BC for the removal of cationic dyes from water contributing to sustainable water treatment, innovative material utilization, waste valorization and climate action.

Keywords: *Adsorption, Biochar, Dye, Methylene blue, King coconut husk*

Valorization of Corn Husk Waste: A Sustainable Natural Dye for Textile Coloration

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Abstract

The utilization of agricultural by products for the preparation of natural dyes, provide a more eco-friendly solution for the excessive usage of synthetic dyes in textile industry. In this research, corn *(Zea mays)* husk was chosen as raw material for the extraction of colorants for the fabric coloration. Colorant extraction parameters were optimized for the highest colorant yield using a water-based alkaline medium. The influence of NaOH concentration (2-12%) on the weight of dried corn husk, material to liquor ratio (1:10-1:30), and extraction temperature (40-80^{0}C) were evaluated. The optimum extraction conditions were found to be 12% NaOH, an extraction bath temperature of 70^{0}C, and MLR 1:10, yielding 6% pigment. To improve the fastness properties and dye fixation on fabrics, different mordants were employed, including pre-, post, and simultaneous with zinc sulphate, iron sulphate, and alum. Additionally, quaternary ammonium-based cationizing agent was used to increase the dye affinity for cotton. Among the mordanting processes, post mordanting with zinc sulphate resulted in the best colour fastness to light. The dyed fabric's properties such as washing, perspiration and rub fastness showed improved performance with various mordants. Mordanted and cationized dyed cotton fabrics showed a deeper colour depth than unmordanted dyed cotton fabric. The colourfastness properties, including washing and perspiration increased to a grade 4 for the fabric dyed with corn husk based natural dye (CHD) when alum was used as the mordant. Furthermore, the resulted dye powder was analysed using Thermogravimetric analyser (TGA), FTIR and particle size analyser (PSA), The study suggests that it is possible to use CHD in the textile industry in sustainable and environmentally friendly way. It concludes that CHD can be a practical alternative to some synthetic dyes.

Keywords: *Colour Fastness, Mordants, Natural dye, Zea mays*

Biochar Surface Functionality as Affected by Base Modifications: FTIR based Principal Component Analysis (PCA)

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Abstract

Biochar (BC), a significant byproduct of biofuel production, is a low-cost, porous, carbonaceous material that has been widely researched for its environmental remediation potential. Its surface features render it capable of water filtration and soil amendments, supporting the sustainable management of byproducts from the biofuel sector. Although the correlation between feedstock type and physiochemical properties has been reported, the effect of modifications remains underexplored. In this study, the correlation between surface functionality and different base modifications of BC obtained from six different feedstocks: three lignocellulosic (Tea Waste (TW), Rice Husk (RH), Saw Dust (SD)) and three non-lignocellulosic (Cow Dung (CD), Chicken Litter (CL), Waste Sludge (WS)) was investigated. Attenuated Total Reflectance-Fourier Transform Infrared spectroscopy (ATR-FTIR) and direct FTIR spectroscopy were used to analyze the surface functionalities of raw and base modified BC. Ten replicates of FTIR measurements were taken for each type of BC. Visual observation of FTIR spectra alone did not clearly differentiate biochar types. However, Principal Component Analysis (PCA) in chemometrics, combined with spectral band analysis, revealed clear correlations among the different base-modified biochar types. PCA of different NaOH, KOH, and NH_3 modified BC of different feedstock show clear separation of clusters of Lignocellulosic and non-lignocellulosic feedstock. Raw biochar was distinguishable from base-modified biochar, with NaOH-modified BC displaying the highest differentiation across all feedstocks. RH-BC was distinct across all modifications. KOH-modified CD-BC, CL-BC, and WS-BC were identifiable. Score plots of ATR-FTIR data revealed that all base modifications of CL-BC, SD-BC, and TW-BC were distinguishable, while direct FTIR data confirmed this for CL-BC and TW-BC. The developed model provided a clear understanding of surface functionality alterations resulting from different base modifications of biochar, a critical factor influencing its adsorption characteristics.

Keywords: *Attenuated Total Reflectance-Fourier Transform Infrared Radiation, Base Modifications, Biochar, Lignocellulosic and non-lignocellulosic Feedstock, Principal Component Analysis*

Sanitary Napkins Disposal Practices Among Non-Residential Women: A Comparative Study in Sabaragamuwa University of Sri Lanka

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Abstract

Menstrual hygiene management in Sri Lankan universities faces challenges such as improper sanitary pad disposal, lack of education, poor institutional support, and social stigma. Despite rising awareness, many students still lack proper disposal practices, leading to health and environmental risks. This study focuses on the disposal behaviors and challenges of non-residential and residential women at the Sabaragamuwa University of Sri Lanka, with the aim of identifying key areas for improvement in menstrual hygiene management. A survey was conducted using a structured questionnaire, involving 186 non-residential and 23 residential women. Frequency distributions and non-parametric statistical tests were used to compare disposal methods and analyze the relationship between residential status and disposal practices. The most used menstrual product was sanitary napkins (97.3%), followed by tampons and menstrual cups (6.0% each). Results showed significant differences ($P<0.05$) in disposal methods between non-residential and residential women. Non-residential women were more likely to burn their waste (44.1%) or dispose of it in public bins (28.5%) due to limited access to private disposal facilities. In contrast, 59.1% of non-residential women faced disposal difficulties, while 40.9% did not, though this was not statistically significant. While disposal practices between residential and non-residential women were not significantly different ($P>0.05$), the residential status moderately affected disposal choices ($P<0.05$, Cramer's V = 0.36). Educational level also influenced disposal awareness and practices among non-residential women ($P<0.05$, Cramer's V = 0.2866). Social stigma and comfort in discussing menstrual waste disposal were significant factors in determining disposal methods. Although 86.0% of participants had access to separate disposal bins, 52.7% of non-residential respondents indicated the need for increased awareness on proper disposal and addressing social stigma (49.5%). The study highlights the need for improved disposal options and educational interventions to address menstrual hygiene and waste management, particularly in environments where women are away from home for extended hours. Policy changes are essential to reduce health and environmental risks associated with improper disposal.

Keywords: *Menstrual hygiene management, Sanitary pad disposal, Social stigma, Educational interventions, Waste management*

Adoption, Challenges, and Potential for Sustainable Farming with Utilization of Bio-Charcoal Enriched Organic Fertilizer

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Abstract

Coconut shell waste, a by-product of coconut oil processing, is rich in carbon and fiber, making it ideal for bio-charcoal production. Bio-charcoal, when used in organic fertilizers, improves soil porosity, enhances water retention, and boosts nutrient availability, fostering healthier and more productive soils. With growing interest in organic farming and sustainable practices, this study investigates the use of bio-charcoal-enriched organic fertilizer as a soil amendment, along with its uptake by farmers in Sri Lanka. The research surveyed 289 farmers involved in both home and commercial farming, focusing on their practices, knowledge, challenges, and beliefs regarding bio-charcoal and compost manure. Data was collected through a standardized questionnaire and analyzed using SPSS software version 22 and Microsoft Excel 2016. The results revealed that 78.8% of the farmers use either compost manure or bio-charcoal, with 88.2% planning to continue or increase its use. Half of the interviewees produce compost and bio-charcoal themselves, while the other half purchase them from local markets. Coconut shell waste, a readily available by-product of coconut oil production, is the primary raw material for bio-charcoal. Most compost production relies on kitchen waste (84%), garden trash (79%), and animal feces (31.5%). Regarding experience, 66.6% of farmers have been using bio-charcoal and compost for over five years, reflecting a growing trend toward organic fertilizers in Sri Lankan agriculture. However, challenges persist. Sixty percent of farmers reported not knowing how to produce and apply bio-charcoal-enriched fertilizers effectively. Additionally, 66.2% cited the lengthy compost production process, 42.3% mentioned a lack of raw materials, and 23.9% were unaware of the benefits of compost. Based on the data, it is clear that with targeted support, such as awareness campaigns, training, and subsidies, the widespread adoption of bio-charcoal and compost manure can significantly improve soil quality, boost agricultural productivity, and promote long-term environmental sustainability in Sri Lanka's farming sector.

Keywords: *Bio-charcoal, Organic fertilizer, Water retention, Sustainable farming, Compost manure*

Drug Discovery and Development

Assessment of the Larvicidal Potential of *Catunaregam spinosa* Seed Extract Against *Aedes aegypti* Mosquito Larvae

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Abstract

Dengue is a common vector-borne disease prominent in tropical and subtropical climates. It causes losing millions of human lives per year around the world. *Catunaregam spinosa* (Rubiaceae) is an underrated medicinal plant in Sri Lanka which withholds a long history relationship between its larvicidal activity against mosquito larvae. Present study examined the phytochemical profile and toxicity of seeds of *C. spinosa* against larvae of *Aedes aegypti* to provide a scientific validation to the embedded property amidst of disclosing a novel natural-based alternative for synthetic larvicides. Mosquito cultures were established according to the guidelines by World Health Organization and obtained fourth instar larvae were tested against a series of concentrations of aqueous seed extract (75.0, 125.0, 250.0, 500.0, 1000.0 mg L^{-1}). Pre-conditioned water and 0.01 % Dimethyl sulfoxide (DMSO) were the negative and solvent controls respectively. Larvae mortalities and the teratogenic effects were observed after 24 hours and the mean percentage mortality, median and maximum lethal concentrations were calculated using SPSS (Statistical Package for Social Sciences) software. Concentration dependent mortality, sub - acute toxicity, teratogenic effects and the computed 24 h, LC_{50} of 233.67 mg L^{-1} and LC_{90} of 659.93 mg L^{-1} revealed the moderate larvicidal activity of the seed extract. Preliminary phytochemical analysis reported the presence of alkaloids, coumarins, saponins and flavonoids. Gas chromatography mass spectrometry identified butanoic acid, octadecanoic acid, n-hexadecenoic acid and palmitic acid along with 19 different compounds in the extract. Stomach toxicity, neuro toxicity and the free radical damages caused by bioactive compounds might associate with the larvicidal potential of *C. spinosa*. In conclusion, the study unveiled a lodged property in an abandoned plant in Sri Lanka to get the well use whilst supporting the green-revolution and sustainable health system via developing bio-larvicides using natural compounds available in *C. spinosa*.

Keywords: *Aedes aegypti, Catunaregam spinosa, larvicide, phytochemicals, seeds*

Comparative Microbiological, Physiochemical and Phytochemical Analysis of Sri Lankan Traditional Medicine "Nawarathna Kalka" on Different Market Samples; Towards Standardization

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Abstract

Nawarathna Kalka (NK) is a traditional herbal formulation used for gastrointestinal disorders (diarrhea, abdominal pain, hematochezia, indigestion) and inflammatory conditions like rheumatoid arthritis. Ensuring consistent quality is essential for therapeutic efficacy. However, NK is produced by multiple manufacturers without standardized specifications, leading to variations in quality, efficacy, and safety. Differences in microbiological and physiochemical properties can impact consumer health. This study designed to compare microbiological, physiochemical, and phytochemical properties of NK from five brands available in the local market. Moisture content, pH, total ash, acid-insoluble ash, and extractable matter (water and ethanol) were analyzed along with microbiological assessments of total bacterial, yeast and mold count and specific pathogenic bacteria (*Escherichia coli*, *Salmonella* spp., *Shigella* spp.) following WHO guidelines. Thin Layer Chromatography (TLC) was used to assess intensity variations and spot differences. The total bacterial count was within the acceptable limit ($<10^5$), however total yeast and mold count exceeded the standard ($<10^3$) in all samples. No specific pathogenic bacteria were detected. The moisture content, pH, total ash and acid insoluble ash values differed among the brands. The moisture content ranging from 15.14±0.15(mean ± standard deviation) to 18.08±0.21, which influenced microbial stability. pH ranges 3.97 ±0.03 to 4.06 ±0.08 indicating slight acidity differences. Total ash ranging from 1.41±0.38 to 2.60±0.09 may due to the different processing methods. Acid insoluble ash levels also varied remarkably, ranging from 0.07±0.02 to 0.20±0.24 showed highest residue content. Notable differences were observed in water -soluble extractable matter and ethanol-soluble extractable matter, with the ranges of 53.75±8.00 to 61.70±1.33 and 26.63±3.37 to 47.85±4.58 respectively. TLC profiles showed similarities and intensity variations among the brands. The findings revealed significant variations in certain physiochemical properties and microbiological quality among the brands when compared, highlighting the need for standardization to ensure the uniformity, efficacy, and safety of NK formulations across manufacturers.

Keywords: *microbiological, Nawarathna Kalka, physiochemical, standardization, TLC*

Formulation and Evaluation of Herbal Hair Gel from *Cyclea peltata* Leaf Extraction and *Aloe vera* Leaf Extraction

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Abstract

The aim of this research was to formulate an anti-dandruff herbal hair gel using *Cyclea peltata* and Aloe vera as a natural, eco-friendly alternative to synthetic hair gels, offering moisture, scalp nourishment, and gentle styling without harsh chemicals while ensuring safety and effectiveness. *Cyclea peltata* enhances scalp health by promoting wound healing, reducing allergies, and providing a cooling effect. Its bioactive compounds, including flavonoids, tannins, and saponins, contribute to the nourishing properties of the herbal gel. *Cyclea peltata* was extracted using the maceration process with 80% methanol followed by storage at room temperature in dark for three days. *Aloe vera* was extracted using the aqueous method. Four different hair gel formulations were prepared using *Cyclea peltata* and Aloe vera containing varying concentrations as active ingredients. Carbopol 940, polyethylene glycol, methyl paraben, glycerin, triethanolamine and lavender oil were usd as a excipient and evaluated. Formulations F1, F2, F3, and F4 were assessed based on parameters such as colour, odour, consistency, clarity, homogeneity, pH, spreadability, skin irritation, and stability. Among all formulations the most probable formula, F4 (*Cyclea peltata* 3% and Aloe vera 3%), had a golden yellow color, a clear appearance, a distinct aroma, and a suitable pH of 5.56 along with good homogeneity and spreadability (16.81). The skin irritation test was conducted on five volunteers, and no signs of irritation were observed. Stability testing for F4 was conducted for four weeks and the product remained stable throughout the period of testing. According to the preliminary physiochemical and stability data obtained for the F4 formulation, it indicates potential to be used as herbal hair and scalp care product. However, further studies in terms of supporting its antidandruff efficacy and safety profile for a broader population should be explored.

Keywords: *Aloe vera, Cyclea peltata, Dandruff, Hair gel*

Analytical Method Development and Validation for Quantifying the Active Pharmaceutical Ingredient (API) in Aspirin Tablets

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Abstract

This study develops a cost-effective UV-visible spectroscopic method to quantify aspirin in commercial tablets, an alternative to High-Performance Liquid Chromatography (HPLC). This involved peak identification of various aspirin sources; standard, commercial tablets, and laboratory-synthesized aspirin [Future work will include Nuclear Magnetic Resonance (NMR) characterization of lab-synthesized aspirin]. Purity of the three aspirin sources was confirmed using Fourier Transform Infrared Spectroscopy (FT-IR) (C=O stretch at 1750 cm^{-1}), Fluorescence Spectroscopy, Thin Layer Chromatography (TLC), single spot with 1:1 hexane: ethyl acetate mix, and melting point analysis (133 °C – 137 °C). UV-visible spectroscopic analysis identified four peaks, the main peak at 226 nm for acetylsalicylic acid, with smaller peaks for salicylic acid, methyl salicylate, and acetic acid. Degraded impurities were identified and quantified via fluorescence spectroscopy, TLC with staining agents, lab-synthesized standards, and existing research. Derivative UV-visible spectroscopy will be used to improve selectivity, with future validation by HPLC. The Limit of Detection (LOD) and Limit of Quantification (LOQ) were calculated using regression residuals and the calibration curve slope. An 8-point calibration curve was developed using a standard aspirin sample, and tablet analysis was done via standard addition in acetonitrile. Validation showed excellent linearity (R^2: 0.9999) in the 4.00–20.00 ppm range, with high accuracy (spike recovery), precision (Relative Standard Deviation, %RSD ≤ 2), and sensitivity (LOD: 0.162 ppm, LOQ: 0.490 ppm). Stability studies at room temperature and refrigerated conditions (4.00, 12.00, and 20.00 ppm) showed excellent stability over 14 days. Market analysis showed API content of 96.3%–102.4% in 100 mg tablets and 98.7%–104.1% in 75 mg tablets, confirmed by titration with 1.00 M NaOH and HCl. Ethanol (alternative solvent) performed well (LOD: 0.324 ppm, LOQ: 0.983 ppm, R^2: 0.9998), satisfying the ±10% stability criterion. Robustness analysis showed aspirin's stability at low temperatures and acidic pH, with rapid hydrolysis at high temperatures, especially in alkaline conditions. This offers an eco-friendly method to quantify APIs aspirin drugs.

Keywords*: Aspirin, ICH guidelines, Method development, Method validation, UV-visible spectrophotometer*

Method Development and Validation for Quantifying the Active Pharmaceutical Ingredient in Paracetamol Based Drugs Using UV Visible Spectrophotometry

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Abstract

Paracetamol (PCM) is a widely used analgesic and antipyretic drug that exerts its therapeutic effects primarily through the inhibition of cyclooxygenase pathways in the central nervous system, reducing pain and fever with minimal anti-inflammatory activity. This study introduces a simple, accurate, cost-effective UV-Visible spectrophotometric method to determine the active pharmaceutical ingredient (API) in PCM-based drugs. The method utilizes methanol and water as diluents in a 25:75 (v/v) ratio and analyzes commercially available PCM-based drugs in Sri Lanka under both room temperature and refrigerated storage conditions. The developed method was validated according to the International Conference on Harmonization (ICH) guidelines, assessing several key parameters, including accuracy, precision, linearity, limit of detection (LOD), limit of quantification (LOQ), and stability. The maximum absorption wavelength (λ_{max}) was observed at 244.0 nm and selected for quantitative evaluation. Accuracy was tested using the standard addition method, yielding mean recoveries ranging from 95.91% to 106.87%. Precision was evaluated using six replicates of three concentrations, with inter-day precision assessed over three days and intra-day precision within one day. The relative standard deviation (%RSD) remained below 2% for both precision values. Linearity was established over a concentration range of 3.00–12.00 ppm, with a correlation coefficient (R^2) of 0.999. LOD and LOQ values were determined to be 0.09006 ppm and 0.2729 ppm, respectively. Stability testing revealed that the developed method remained stable up to 21 days under both room temperature and refrigerator conditions, with deviations within the acceptable range of ±10% from the initial value. Market sample analysis was conducted using the percentage recovery method, and the actual API concentrations in 500 mg tablets ranged between 497.83 mg and 533.85 mg, meeting the acceptance criteria suggested by the ICH. The developed method is found to be simple, accurate, economical, and eco-friendly, as it avoids the use of harmful reagents.

***Keywords**: ICH guidelines, method development and validation, paracetamol, UV-visible spectrophotometry*

Feasibility Study of ^{131}I Radioisotope Production in Sri Lanka

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Abstract
^{131}I is the predominant isotope utilized for both therapeutic and diagnostic applications in cases of thyroid cancers and hyperthyroidism. In 2022, Sri Lanka reported 1,706 new cases of thyroid cancer, representing 5.1% of the total cancer cases in the country. The radioisotope has not been produced in Sri Lanka and has high demand for treating patients. The radiopharmaceutical drug of ^{131}I is imported from neighboring counties with an average cost of USD 154 per capsule making a significant impact on the economy. This study examines the feasibility of producing ^{131}I in Sri Lanka using the neutron activation of ^{130}Te, which constitutes 34% of natural tellurium dioxide (TeO_2). 5 g of Te samples were irradiated in the neutron activation facility at the University of Colombo to produce ^{131}Te. It subsequently decays into ^{131}I, which has a half-life of 8 days. The activated samples were analyzed using gamma spectroscopy to identify radioactive impurities and estimate the production activity. Wet distillation method was used to separate I from Te precursor and separated Te solution was reactivated to produce a new ^{131}I sample. This process was repeated to accumulate a higher activity of ^{131}I per sample. The separation process was initially optimized for chemical concentrations and distillation time using ^{128}I to minimize the cost. The signature peak of 364 keV for ^{131}I was observed in the separated solution confirming the ^{131}I production. The gamma rays corresponding to activation of Te and other iodine isotopes were not observed revealing the radioactive purity of the final product. The first cycle of activation produced 29.3 ± 0.3 Bqg^{-1} of ^{131}I with a potential for increasing activity by performing several cycles and processing multiple samples simultaneously. The results showed a cost-effective method to produce ^{131}I in Sri Lanka.

Keywords: *Radioisotope, Neutron activation, Gamma spectroscopy, Tellurium Dioxide, Wet distillation, ^{131}I Production.*

Phytochemical Variation and Anti-hyperlipidemic Potential in *Camellia sinensis*: A Comparative Study of Sri Lankan Cultivars

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Abstract

Camellia sinensis; family Theaceae, is a widespread plant consumed as a common beverage worldwide. The plant processes several known therapeutic properties including antioxidant, anti-inflammatory, antimicrobial and anti-hyperlipidemic effects. . Literature showed that flavonoids, tannins, alkaloids, and saponins are among the many found in *C. sinensis* that have anti-hyperlipidemic effects. Hyperlipidemia is a major risk factor for coronary artery disease. These substances restrict fat absorption, lower oxidative stress, and control cholesterol metabolism. This research was mainly targeted at conducting qualitative phytochemical analysis and investigating the anti-hyperlipidemic activity of *C. sinensis* leaf extracts from the Balangoda and Bandarawela area. Fresh tea leaves were air-dried and extracted using ethanol and water (1:10) in a Soxhlet apparatus at 55°C for 3 hours and analyzed via FT-IR, GC-MS, and phytochemical screening. FT-IR revealed C-O stretching vibrations (glycosides, oxygenated compounds) and hydroxyl groups (polyphenols, flavonoids, tannins). Phytochemical analysis confirmed flavonoids, tannins, alkaloids, and saponins, with GC-MS validating these compounds. Saponins and flavonoid content were determined by performing the Froth test and Shinoda test respectively. The findings showed notable differences in the phytochemical composition of *C. sinensis* with respect to their origin, where the aqueous extract of the Balangoda variety showed greater levels of flavonoids and saponins. The substantial phytochemical diversity and differing levels of anti-hyperlipidemic potential across Sri Lankan *Camellia sinensis* cultivars are highlighted in this study. Notably, Balangoda variety showed the strongest lipid-lowering action, indicating that it may play a promising role in the creation of pharmacological formulations or functional foods for the treatment of hyperlipidaemia. To maximize its use in health interventions and confirm its therapeutic potential, more investigation is necessary.

Keywords: *Camellia sinensis, Anti-hyperlipidemic, Geographical area, Saponins, Flavonoids*

Mechanical Engineering Technology

Gamification to Boost Up Training in Manufacturing – An Industry-4.0 Based Approach

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Abstract
The rapid evolution of industrial landscapes necessitates effective employee training to keep pace with industry 4.0 technological advancements. Traditional methods, such as classroom-based instruction and printed manuals, often fail to engage employees and ensure long-term knowledge retention, with research highlighting retention rates as low as 10-20% within a week. This study explores the integration of gamification principles with Industry 4.0 technologies augmented reality (AR), virtual reality (VR), and mobile applications to address these challenges and enhance employee training on production lines. Focusing on 13A plug socket assembly line in a leading electrical manufacturer in Sri Lanka, the research involved developing a gamified mobile application. The mobile application was designed with the influence of motivational theories like Self-Determination Theory and Bartle's Taxonomy, incorporating interactive features such as drag-and-drop tasks, real-time feedback, leaderboards, and progress tracking. Pre- and post-training data, learning curves, and forgetting curve analyses were utilized to measure the application's impact on learning speed, engagement, and skill retention. Results revealed that new recruits achieved faster learning stabilization, reducing task completion times by 30% compared to traditional methods. Post-training forgetting curves showed improved skill retention among trainees. While experienced workers demonstrated minimal improvements due to prior expertise, the gamified approach enhanced knowledge consistency and task accuracy. A post-training survey indicated high user satisfaction, particularly regarding engagement and ease of use. The study concludes that gamified training effectively accelerates learning and enhances knowledge retention for new employees while maintaining skill consistency among experienced workers.

Keywords: *Gamification, Industry 4.0, Employee training, Training motivation, Training engagement*

AI-Driven Microcontroller System for Leaf Maturity Detection: Toward SMART Operations in Agriculture

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Abstract

Artificial intelligence (AI) is an emerging technology that agriculturists can widely use to optimize routine operations such as harvesting and chemical applications. This study was conducted to develop a microcontroller-based AI model capable of identifying the age and different maturity levels of tree leaves. The process began by selecting a suitable common tree and gathering three sample leaves based on their age and maturity. The ESP32 CAM module was chosen as the microcontroller. Test and training images were collected using the built-in camera of the module. In the sampling process, twenty-five images were collected from each sample, and the three sets of samples were classified as Sample 1, Sample 2, and Sample 3, according to their maturity levels: young, mature, and old. The detection process primarily focuses on leaf color and length. For the machine learning phase, the Edge Impulse commercial training model was used to train the datasets. During the training process, a low learning rate was applied to improve the model's accuracy and detection capability. After training, the model demonstrated an ability to verify and validate detection with an accuracy rate of approximately 92.9%. In the final stage, the AI model for detecting leaf age and maturity was integrated with the ESP32 CAM module and tested with real-world leaves. During the analysis and detection phase, the model was able to identify the age and maturity level of the leaves with an accuracy rate ranging from 50% to 90%. Challenges during the process included varying sunlight intensities and background color interference. In the future, this AI model is planned to be further enhanced with a customized leaf detection and training system.

Keywords: *Artificial-Intelligence, ESP32-CAM, Machine-Learning, Microcontrollers, Leaves-Detection*

Comparative Study on Enhancing Aerodynamic Performance of Fuselage in Vertical Take-Off and Landing Aircrafts Using Computational Fluid

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Abstract

This research explores the application of biomimicry, inspired by the streamlined structure of a shark, to enhance the aerodynamic performance and cargo delivery efficiency of Vertical Take-Off and Landing (VTOL) aircraft. Sharks are known for their exceptional hydrodynamic design, which reduces drag and enables smooth, efficient movement through water. This study adapts the unique structural features of a shark to redesign the fuselage of a modern VTOL aircraft, achieving reduced drag and improved performance. The redesigned fuselage model incorporates modifications to optimize internal space for increased cargo capacity. 3D models of the baseline fuselage and the shark-inspired structure were created using the SpaceClaim design platform. Simulations were conducted in ANSYS Fluent simulation software, focusing on parameters such as drag coefficient, airflow pressure distribution, and velocity profiles. Mesh generation, material properties, and boundary conditions were carefully implemented to ensure consistency across all designs. Each model was subjected to identical airflow pressure and velocity conditions during the simulation. Results demonstrated that the shark-inspired fuselage design achieved a significantly lower drag coefficient compared to the baseline model, contributing to smoother airflow and reduced aerodynamic resistance. Furthermore, the modified design increased cargo delivery capacity without compromising flight performance. This study highlights the potential of nature-inspired designs to revolutionize VTOL aircraft by demonstrating how a shark-like structure can enhance aerodynamic efficiency while addressing practical requirements such as cargo space.

Keywords: *VTOL aircraft, Biomimicry, Shark-inspired design, Aerodynamic efficiency, Drag reduction*

Design, Development, and Testing of Automated Coolant Injection System for Bench Drilling Machine

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Abstract

Failure to apply coolant during bench drilling can result in work piece damage, excessive burr formation, and drill bit overheating. Many machine operators use a brush to apply coolant manually, which can be ineffective. A portable cooling system can be developed to inject only coolants during operations like drilling while maintaining optimal temperatures and preventing work piece damage. The prototype was designed using SolidWorks software. The coolant reuse system incorporates 3D-printed filter components with an internal fabric filter for improved coolant purity. A cooling pad, cut from a 0.5 mm galvanized sheet and spot welded, connects the filtration system. The coolant sump, made from fiber, allows for the use of both water-based and oil-based coolants. Additionally, 3D-printed hose connectors ensure a precise fit with the nozzle. The nozzle set bar is drilled to match the nozzle dimensions. For automated coolant injection, the system utilizes an HC- SR04 ultrasonic sensor, three push buttons to select from three thickness ranges, a 12V DC water pump, an LED indicator, an I2C LCD, and an external 12V power source. The sensor detects the drill bit movement and triggers, the pump to inject coolant in a controlled manner, adjusting the flow based on work piece thickness. Testing demonstrated that the system significantly reduces burr formation and overheating, effectively addressing several challenges faced by bench drill operators. Experiments are ongoing to identify what future development will look like. This solution benefits mass production industries by enhancing efficiency, reducing rejection rates, and extending tool life. By integrating automated coolant injection and filtration, this system offers an innovative and cost-effective solution for improving drilling performance.

Keywords: *Coolant injection, Bench drilling, Ultrasonic sensor, 3D printed filtration, Work piece protection.*

Comparative Study on Mixing Efficiency of Paper Pulp Beaters Using Computational Fluid Dynamics

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Abstract

Paper based packaging material is an emerging solution as a replacement of non-bio degradable packaging materials. The pulp making process must ensure uniform material properties and improve mixing and beating efficiency by maintaining a turbulent flow with reduced stagnation points. This study focuses on designing, fabricating, and performance analysis of a mixing tank for producing paper based pulp. The proposed agitator and the tank area were designed using the SolidWorks designing platform according to the pre-calculated dimensions and the exported model was simulated using Ansys 16 software platform with fluent solver, enabling detailed 3D models of paper beater configurations. The simulation of velocity and turbulent kinetic energy in cylindrical and cubical tank sections offers valuable insights for optimizing tank design in mixing processes, emphasizing the importance of geometry in achieving desired outcomes. This simulation helps to identify optimal design parameters for improved pulp consistency and reduced energy consumption. Furthermore the simulation was extended by assigning a minor offset to the agitator assembly for both shapes, enhancing turbulence for better beating and mixing, which requires further analysis. To enhance mixing uniformity and prevent material buildup, six rectangular blades were fixed at different levels on the agitator shaft with a slight angle from vertical side to horizontal, as improper angling and shaping could create streamlines that reduce turbulence inside the tank. The result shows that the cylindrical tank demonstrated superior mixing performance and high efficiency, with uniform turbulence flow, effectively preventing stagnant areas. In contrast, the box-shaped tank demonstrated lack of mixing efficiency, necessitating an increase in agitator RPM to enhance turbulence flow. The study emphasizes the cylindrical tank's effectiveness in mixing with lower power requirements and high turbulence flow, making it an energy-efficient option for this unit.

Keywords: *Agitator Design, Computational Fluid Dynamics, Mixing Tank, Simulation, Velocity Distribution*

Comparative Analysis of Calorific Values in Ethanol-Gasoline Blends with Carbon Nano Spheres as Additives to Enhance Combustion Efficiency

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Abstract

The rise in global demand for fossil fuel is significant to enhancing the efficiency of gasoline combustion is critical for reducing fuel consumption and emissions. The objective of the blending is to improve the performance of pure gasoline by adding carbon nanospheres (CNS) blended with ethanol as a nanofluid. In this study, three different samples were experimentally investigated to analyze calorific values using an automatic calorimeter (chiller 5E-C5508) with varying fractions of volume prepared by using a two-step direct mixing method with ethanol (0.1%) and gasoline (50 ml) combined with CNS at weight fractions of 0.01%, 0.05%, and 0.1%. Based on the analyzed calorific values of the samples, the 0.05% carbon nanospheres (CNS) blend release the highest calorific value (CV) of 43853 J g^{-1}, optimizing its potential to have the highest energy output significantly, while the second highest CV of 43343 J g^{-1}, was released by 0.01% carbon nanospheres (CNS) blend. The lowest CV of 41677 J g^{-1}, was released by 0.1% CNS blend, likely due to excessive particle clustering, which can hinder uniform combustion. This experimental analysis suggests maintaining optimum calorific value, attributed to improved fuel combustion characteristics. This experimental analysis tendency highlights the importance of choosing appropriate carbon nanospheres (CNS) is significant to maintaining optimum energy density. Additionally, this study showcases the potential of carbon nanospheres as an applicable fuel additive, enhancing combustion efficiency and minimizing environmental impact. Moreover, this study demonstrates the capability of nanomaterials such as carbon nanospheres, of improving gasoline combustion performance and efficiency tends to way of more sustainable future fuel additive solutions.

Keywords: *Carbon Nanospheres, Calorific Value, Gasoline Blends, Fuel Additives, Combustion Efficiency*

Comparative Analysis of Calorific Values in Ethanol-Enriched Gasoline and Other Fuel Blends to Assess Efficiency

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Abstract

Enhancing the energy efficiency of gasoline through calorific value analysis is a major concern of gasoline and critical due to increasing fuel consumption in the transportation sector. Fuel additives play an important role in enhancing the efficiency of gasoline vehicles. This study experimentally investigates the effects of ethanol and two commercially available products as additives on gasoline calorific value with different volume fractions. The oxygen content of ethanol promotes more complete combustion, thereby reducing harmful emissions, such as CO_2, CO, Hydrocarbons (HC), Sulfur Dioxide (SO_2) and Nitrogen Oxides (NO_x). This experiment created dispersions in nine samples with volume fractions from 0.1% to 0.9%, with step size 0.1 and two commercially available additives with a volume fraction 0.1% with an equal amount of gasoline. A two-step direct mixing method was used for sample preparation and calorific values were measured with the automatic calorimeter (chiller 5E-C5508). The base fluid (0% ethanol) exhibited the highest calorific value at 44914 Jg^{-1}, while the 90% ethanol blend recorded the lowest calorific value at 19979 Jg^{-1}. The 10% ethanol blend achieved a calorific value of 44091 Jg^{-1}, showing minimal reduction compared to pure gasoline, making it the most efficient blend in terms of maintaining energy content. The findings reveal that while ethanol reduces calorific value due to its lower energy density compared to gasoline, blends with lower ethanol concentrations (10%-30%) strike an optimal balance between energy efficiency and ethanol's environmental benefits. The two samples prepared by using commercially available fuel additive products (Emsol and Soltron) recorded calorific values of 38805 Jg^{-1} and 45038 Jg^{-1} respectively. Among the two samples, one exhibited a marginal increase in calorific value compared to pure gasoline. Based on these findings, 0.1 vol.% ethanol concentration is recommended for further study to improve gasoline fuel properties.

Keywords: *Gasoline, Ethanol, Calorific value, Energy*

Design, Development, and Experimental Testing of a Propeller Test Rig for Computational Fluid Dynamics Model Validation in Propeller Performance Analysis

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Abstract

Computational Fluid Dynamics (CFD) is a powerful technique for studying fluid flow around objects. It can be used to simulate the flow of air over the blades of a propeller, yielding significant insights into its performance. Accurate thrust measurement of propellers is critical for optimizing the performance of various types of drones. However, the developed simulation model must be validated with any other method such as an experimental method to ensure the accuracy of the results. Hence, in this comparative study CFD was used to evaluate the thrust performance, power consumption, and mass flow rate numerically while validating results with the developed test rig. For the analysis, two drone propeller designs were used, which are propeller A (8 × 4.5 inches) and propeller B (10 × 4.5 inches). The Ansys fluent 16 simulation platform was used to simulate the aerodynamic characteristics of the propellers, which were designed using SolidWorks 2023 designing software. The CFD analysis was conducted using the k-ω SST (Shear Stress Transport) turbulence model, with detailed meshing strategies to capture the flow dynamics from 1000 to 5000 revolutions per minute(RPM) range in 1000 RPM step size. All simulated propellers were tested experimentally under the same operating conditions to validate the simulation model. The test rig was equipped with a precise load sensor and controller setup to measure the thrust force acting on the propeller and to evaluate the thrust measurements of the specified propellers. The experimental setup validates the simulation results under low spinning velocities and 10% - 40% variation was observed at higher rpms. Higher RPMs cause discrepancies in the CFD model due to turbulence, increased velocity, and complex boundary layers. Enhancing mesh resolution, turbulence models, and transient simulations improves accuracy. Additionally, these experimental data will be utilized to further optimize this simulation setup.

Keywords: *CFD, Finite Element Analysis, Ansys Fluent, Experimental Validation, Propeller Performance*

Nuclear Attack Radiation Impact Study on Geographically Varied Educational Institutional Environment

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Abstract

After the Second World War humans were able to occupy nuclear technology based subjective knowledge and applied that knowledge in different areas mainly in fields of energy and military. Through this experiment tried to identify the radiation impact on educational institution environment which is located in a geographically varied location in Sri Lanka. The main purpose of this study was to build the institutional structures considering upcoming future nuclear threats and accidents for save valuable human lives. Considering security reasons this tested location was masked. For this case study used the NUKEMAP simulator and as the detonation device selected the Davy Crockett nuclear device equals to 20t of TNT. Under the conditions here mainly defined the average wind speed as 19.2mph and defined the burst location on the ground. For the calculations simulator assumed 760 persons averagely move through the test site considering annual average human movements. Through this simulation identified this kind of small nuclear device can cause for 370 fatalities and 150 injuries from total movements mentioned above. As test site for this experiment selected the institution playground, when considering about the surface impact this created a crater with inner radius 5.24m,depth of 2.51m, and a lip radius 10.5m.In the mushroom cloud it was altitude 0.81km, head radius 132m and head height 232m. This experiment represented mountains and slopes based geographical locations, can reduce the thermal radiation impact and as well as buildings and other structures can work as a barrier to reduce the damage. In this kind of scenario people can survive using As Low As Reasonably Achievable (ALARA) method by following time, distance, and shielding principles. Through this kind of simulation methods can evaluate the future impactable threat from nuclear attacks and can take preventive actions for those attacks.

Keywords: *ALARA, Davy-Crockett, Mushroom-cloud, Nukemap, TNT*

Computational Fluid Dynamics (CFD) Analysis of Brake Wear Particle Behavior Under Different Driving Conditions

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Abstract

Non-exhaust emission control including tire particles and brake wear particle control is emerging since the world is rapidly moving from combustion engines to electric vehicles. Electric vehicles are capable of reducing exhaust emissions but still generate particles from brakes and tires. According to the EURO 7 standard, there are already imposed regulations which state that automotives need to adhere to non-exhaust emissions limits to control the air quality and reduce the environmental impact, especially in urban areas. This study investigates the aerodynamic behavior and deposition of break particles generated during braking at various driving speeds, and breaking intervals using computational fluid dynamics (CFD). A ventilated brake rotor with standard brake pads was modelled using SolidWorks 22 designing software and Ansys 16 fluent solver with a discrete phase model was used to track the particle paths. The simulation considers key aerodynamic parameters such as wind speed, brake disc spinning speed, and caliper location. The study aims to provide insights into the influence of vehicle aerodynamics on particle dispersion and accumulation, contributing to improved mitigation strategies for non-exhaust emissions. In conclusion, results show that there is a potential to accumulate brake particles at a specific area with existing brake rotor designs where an improved rotor design could accumulate the majority of particles at an inbuilt particle collector. Results will be validated against experimental or empirical data to enhance model accuracy.

Keywords: *Non Exhaust Emissions, Automobile Emissions, Computational Fluid Dynamics, Particle Tracking, Brake Wear*

Experimental Study on Enhancing Mechanical, Thermal Properties and Biodegradability of Paper Pulp-Based Packaging Materials

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Abstract

Conventional plastics have been widely produced and utilized in packaging applications for decades. However, the petroleum-based composition of these conventional plastics makes them non-degradable, leading to significant environmental concerns. As a sustainable alternative, biodegradable materials have gained attention in various industries to mitigate the adverse effects of non-biodegradable plastics. This experimental study focuses on improving the mechanical and thermal properties of paper pulp-based biodegradable materials specifically for food packaging applications. Cylindrical shaped samples were fabricated using the wet compression molding method, incorporating 10% (w/w) sugarcane bagasse ash (SCBA), wheat flour (starch), and natural lignin to evaluate thermal conductivity under 40 ^{o}C of mean temperature. Additionally, another set of samples with varying amounts of SCBA, calcium carbonate ($CaCO_3$), and starch was prepared for bending strength analysis. Biodegradability was assessed using multiple sheet samples, each 1 cm in width. All prepared samples were oven-dried at 105°C for 48 hours to eliminate excess moisture. Bending testing was conducted using a universal testing machine to measure tensile and bending strength, while a solid thermal conductivity meter was employed for thermal property analysis. The biodegradability assessment was performed in a controlled natural ecosystem. Results indicated that pure paper samples exhibited the highest tensile and bending strengths. Samples containing SCBA showed enhanced biodegradability, with increased SCBA content further promoting degradation. The highest thermal conductivity was observed in samples with 10% starch, whereas lignin-enhanced samples exhibited the highest thermal resistivity of 0.07072 m^3K/W. In contrast, starch-containing samples had the lowest thermal resistivity. Samples with $CaCO_3$ demonstrated intermediate thermal conductivity and resistivity values.

Keywords: *Biodegradable Materials, Mechanical Properties, Thermal Properties, SCBA, Natural Lignin.*

Electrical and Electronic Engineering Technology

An Experimental Study on Performance Degradation of Solar PV Systems Due to Industrial and Environmental Soiling

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Abstract

Solar photovoltaic (PV) technology is a widely adopted renewable energy solution for sustainable power generation. However, soiling significantly affects their performance, leading to efficiency losses. This study examines the impact of different types of soiling on PV efficiency, specifically natural dust, tea factory dust, construction site dust, and ash dust. The objective is to quantify the power reduction caused by these contaminants and assess their impact on PV performance in regions near industrial sites. To simulate real-world dust accumulation, an experimental setup was developed using 560W solar panels (2279×1134 mm) exposed to four 500W halogen lamps providing constant irradiance. Various dust samples were manually applied to the panels, and performance was analyzed under controlled conditions. After dust application, the system was allowed to stabilize until the reference temperature was reached before measuring voltage and current. Under clean conditions, the open-circuit voltage (voc) was recorded at 45.7V, with a current of 0.90A, power output of 41.13W, average irradiance of 192Wm^{-2}, efficiency of 8.30% and a temperature of 27.65°C. When 12g of each dust sample was applied, the results showed significant efficiency drops: natural dust (voc: 44.3V, 0.80A, 35.44W, 7.15%), tea factory dust (voc: 45.2V, 0.78A, 35.26W, 7.12%), ash dust (voc: 45.2V, 0.80A, 36.16W, 7.30%), and construction site dust (voc: 44.1V, 0.80A, 35.28W, 7.12%). Among these, tea factory dust caused the most significant efficiency decline. The findings highlight the critical impact of dust accumulation on solar panel efficiency, particularly in areas near tea factories and construction sites. This study emphasizes the need for effective cleaning strategies to optimize solar energy production in such environments.

Keywords: *Efficiency loss, Industrial dust impact, Photovoltaic performance, Renewable energy, Solar PV soiling*

Design and Development of Nanofluid based Cooling System to Enhance the Efficiency of Li-Ion Batteries and Identify the Thermal Properties using Microcontrollers

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Abstract

In today's world, researchers conduct research on nanofluid-based coolants for different industrial applications due to the superior thermo-physical properties of nanofluids. In this study, a test bed was developed to study the performance of Li-Ion batteries in different operational temperature conditions, using a closed loop active cooling system, working with nanofluids as coolants. In this study, a complete test bed was developed to study the efficiency of Li-Ion batteries using nanofluids under different temperature conditions. Arduino UNO R3 microcontroller was used with eight KY-028 temperature sensors, a DHT 11 humidity sensor, and a YF-S201 flowrate sensor, to collect the data and to control the cooling system. A L298N motor driver was used to control the water pump and relay switch to control the thermoelectric peltier cooler. In addition to that, this microcontroller-based data acquisition system can provide sensor readings as a spreadsheet-based document in tabular format. An ESP 32 microcontroller is used to validate the collected data through sensors during the operation of the system. According to the identified test results, the calculated error ratios between the two microcontrollers. Through the error ratios of flowrate, humidity, and humidity-temperature values represented less than 2% minimal error. Furthermore, Inlet, Front-Inlet, Front-Outlet, and Backward-Inlet showed 5-15% moderate error variation, and the Outlet temperature sensor showed 86% high error ratio in Arduino UNO microcontroller, as well as Backward-Outlet, Thermoelectric Cooler, and Center temperature sensors showed negative 5%-57% error variation in Arduino UNO microcontroller. Therefore, this system is suitable to measure the thermal properties and flow rates of nanofluids. During the entire process, faced some data abnormalities in the Arduino UNO R3 microcontroller-based data, but after calibration and controlling the microcontroller temperature, addressed the abnormal issues. These two microcontrollers are suitable for running this system, and the ESP 32 microprocessor-based microcontroller provided more accurate and reliable results than the integrated circuit-based Arduino UNO R3 Microcontroller.

Keywords: *Arduino-UNOR3, Cooling-System, Microcontrollers, Nanofluids, Thermal-Efficiency*

Bio-Derived Kata Kela (*Bridelia retusa)* Trunk Dye and Metal Oxide Nanostructures for Dye-Sensitized Solar Cells: A Preliminary Study

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Abstract

Dye-sensitized solar cells (DSSCs) are a promising alternative to conventional photovoltaic technologies due to their cost-effectiveness and environmentally friendly materials. This study evaluates the performance of a bio-derived dye extracted from the Kata Kela (*Bridelia retusa*) trunk in combination with nanostructured TiO_2 films as the primary metal oxide framework. The dye was extracted using ethanol and acetone as solvents, with the ethanol-extracted solution exhibiting a more intense red coloration, indicating higher pigment extraction efficiency. Comparative analyses with synthetic dyes demonstrated the sustainable nature of the bio-derived alternative. The UV-Vis absorption spectrum confirmed strong light absorption in the visible region, supporting its role as a photosensitizer. While natural dyes and metal oxide nanostructures have been widely explored, the findings contribute to the understanding of Kata Kela dye's specific properties and its suitability for photovoltaic applications. Performance metrics were recorded, including an open-circuit voltage (Voc) of 0.401 V, a short-circuit current density (Jsc) of 0.42 mA/cm², and a fill factor of 0.48. These results highlight the specific potential of Kata Kela dye in DSSCs, these findings highlight the effectiveness of Kata Kela dye in DSSCs, demonstrating its viability as a natural photosensitizer and providing insights into its optimization for future applications.

Keywords: *Bio-Derived Dyes, Bridelia Retusa, Dye-sensitized solar cells, Nanostructured Materials*

ICET 2025
ISSN 3084-8628

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