ASURS 2024

Applied Sciences Undergraduate Research Sessions

ABSTRACTS

Organized by

Faculty of Applied Sciences
Rajarata University of Sri Lanka

Applied Sciences Undergraduate Research Sessions

ASURS 2024

13th March 2024

Faculty of Applied Sciences

Rajarata University of Sri Lanka

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Message from the Vice Chancellor

With great pleasure, I offer my congratulations as the Faculty of Applied Sciences prepares to launch its sixth Applied Sciences Undergraduate Research Sessions (ASURS) in 2024.

Research has always been a top priority for the Rajarata University of Sri Lanka and has been essential to its academic advancement. The institution has created an atmosphere that promotes systematic research, intellectual engagements, and greater dissemination of diverse areas of study by fostering innovation and improving society. As a result, there is a culture in academia that encourages the pursuit of knowledge for the good of all and supports critical inquiry.

Given that the Faculty of Applied Sciences includes alumni who rank among the top 2% of researchers worldwide, I have every faith in them. Undergraduate research is a vital component of education that fosters students' interest and enthusiasm for the academic goal. The various viewpoints and areas of competence that the disciplines of Physics, Mathematics, Health Promotion, Computing, Chemistry, and Biology brought to ASURS 2024 are not only evidence of the faculty's strength but also a step in the right direction toward a more enlightened future. I value the dedication and hard work of students as well as the guidance provided by academic personnel when undertaking research. The department has made it a practice to give student research participants the chance to present their findings in a scientific setting. Additionally, I urge undergrads to disseminate their research not just among their peers but also with the general public, since this will enable them to have a more significant influence on society.

I am grateful to the faculty staff, the dean, and the ASURS 2024 organizing team for their commitment and perseverance in making this year's research sessions a success. Through collaborative efforts, the faculty has enhanced the university's research culture and added to the overall richness of the academic environment.

I would like to extend my congratulations to every one of the undergraduates who are presenting at ASURS 2024 and wish them all a successful and enjoyable research session.

Professor (Mrs) G.A.S. Ginigaddara
Vice Chancellor
Rajarata University of Sri Lanka
Mihintale

Message from the Dean

I am pleased to extend this message to celebrate the Applied Sciences Undergraduate Research Sessions 2024 (ASURS 2024). The Faculty of Applied Sciences is renowned for its research excellence, exploring various fields and continuously pushing the limits of knowledge. Our efforts over the years have been globally recognized, with our alumni consistently ranked among the top 2% of researchers worldwide by the prestigious Stanford University rankings. This is a testament to the dedication and innovation that define our academic community.

Our research covers a wide range of topics, from studying the smallest molecules to complex animals and human beings. We explore everything from the nature of chemicals to the behavior of human beings and work on producing products for human consumption as well as finding ways to improve human well-being. Our research also includes discovering IT solutions and developing mathematical models that can help advance mankind. ASURS is a platform created to support the next generation of researchers by providing them with an opportunity to share their undergraduate research with the wider research community.

ASURS 2024 is the culmination of our efforts, providing a platform for our young researchers to showcase their undergraduate projects to a wider audience. With 87 oral presentations and 32 poster presentations covering all five departments of the faculty, this event promises to be a celebration of scholarly inquiry and intellectual curiosity. I am particularly pleased to note the introduction of a pre-conference session, as well as the inclusion of engaging activities such as the 3 MT thesis presentation competition and an Art competition, which will undoubtedly enhance the research experience for our students.

I would like to express my heartfelt gratitude to the Organizing Committee of ASURS 2024 for their tireless efforts in bringing this event to fruition within a short timeframe. Their dedication and meticulous planning have been instrumental in ensuring the success of this endeavor. Additionally, I extend my thanks to the academic staff members of the faculty for their invaluable guidance and mentorship, which has played a pivotal role in nurturing the talents of our students. To all the students presenting their findings today, I offer my heartfelt congratulations. Your participation in this event marks the beginning of what I am confident will be a journey filled with discovery, innovation, and impact. May you seize this opportunity as a stepping stone towards your future research endeavors, and may your passion for knowledge continue to inspire others in the pursuit of excellence.

Dr Manoj Fernando
Dean

Message from the Programme Chair

On behalf of the organizing committee, I am pleased to welcome you to the 06th Applied Sciences Undergraduate Research Sessions (ASURS) 2024 organized by the Faculty of Applied Sciences, Rajarata University of Sri Lanka. It has been a great honor and privilege to serve as the Chair of ASURS 2024.

The main objective of ASURS is to provide our final year (both fourth year and third year) undergraduate students with a professional and academic conference platform to present their research findings in aid of initiation of their research careers. This year ASURS portrays high quality research work carried out by our undergraduates under the guidance of their supervisors in the field of Biology, Chemistry, Computing, Health promotion, Mathematics and Physics. The Faculty offers both Bachelor of Science and Bachelor of Science Honors degrees and the general degree programme feature an elective research component with 2-3 credits. ASURS provides a platform for both these students as this time we are proud to announce the participation of eighty seven students those of whom which thirty two are students following general degree programme and shall involve with poster presentations. Aligned with ASURS, several parallel programmes are organized to offer students with opportunities for excellence across diverse fields. For the second time 3MT completion was organized and twenty five presenters participated. For the first time, ASURS is incorporated with pre-conference sessions organized in collaboration with several student associations attached to departments to promote the theme “from students to student”.

This event may have not been possible, if not for the cooperation rendered by Prof. Sanjeewanie Ginigaddara, the Vice Chancellor of the Rajarata University of Sri Lanka. I cannot forget the guidance and cooperation given to us by the Dean of the Faculty of Applied Sciences, Dr. Manoj Fernando. Moreover, I take this opportunity to thank all the Heads of the Department, Assistant Registrar and the team, Assistant Bursa and the team and non-presenting students of the Faculty of Applied Sciences for their support in making this event a success. I would also like to thank the evaluation panels and special guests who attend despite their busy schedules to grace this event. Further, my sincere thanks go to the students and their supervisors for contributing their work to ASURS 2024 and would like to congratulate all the presenters. I thank my editorial board and the organizing committee who took the challenge of organizing this event with a very short notice. A special thanks goes to our sponsor Bank of Ceylon who provided us with financial support.

Dear presenters, may this be a remarkable beginning of your research careers.

Dr. Dilani K. Hettiarachchi
Programme Chair
ASURS 2024

Profile of the Keynote Speaker - Professor Kosala Weerakoon

Professor Kosala Weerakoon is a well-accomplished scholar and educator currently serving as a Professor in Medical Parasitology, Faculty of Medicine and Allied Sciences (FMAS), Rajarata University of Sri Lanka (RUSL). As a young scientist making remarkable strides in his field of expertise, Prof. Weerakoon is an influential figure with an impressive academic background and a proven track record of outstanding research.

He holds a Ph.D in Parasitology from the University of Queensland, and QIMR Berghofer Medical Research Institute, Brisbane, Australia, where his research focused on tropical infections and novel diagnostics. With over one decade of professional experience, Prof. Weerakoon has held key positions in academia. He served as the Head of the Department of Parasitology, FMAS, RUSL, and currently, he is a Visiting-Scientist at QIMR-Berghofer Medical Research Institute, Brisbane, Australia, a Visiting-Lecturer at the Faculty of Medicine, Wayamba University of Sri Lanka, and a fellow of the Royal College of Physicians, Edinburgh, UK. This invaluable experience has fortified his interdisciplinary research approach to drive meaningful advancements in the field of tropical infectious diseases.

Throughout his career, Professor Weerakoon has been honoured with multiple prestigious awards, scholarships, and research grants, highlighting his exceptional contributions to the scientific community. His expertise in the field of tropical infectious diseases has resulted over 60 journal publications in esteemed peer-reviewed scientific journals, with over 1800 citations from fellow researchers worldwide.

In addition to his recent research that focuses on the development of novel molecular tools to improve the diagnosis of many tropical infectious diseases, he is a passionate advocate for public engagement and scientific outreach. He has consistently sought opportunities to communicate his research findings to wider audiences, fostering a greater understanding and appreciation for the field of parasitology.

Abstract of the Keynote Speech by Professor Kosala Weerakoon

Ideas into Reality: Bridging Research, Policy, and Practice

Bridging the gap between research, policy, and practice is crucial for driving substantial societal change, particularly in the developing world. This process involves translating theoretical knowledge and realistic findings into actionable policies and interventions to address key needs of the modern world. Collaboration, communication, and commitment across disciplines and stakeholders are essential for this journey from ideas to implementation.

Research is the key to generating evidence-based insights, and it must translate into implementable policies to guide resource allocation and intervention frameworks at various levels. The transition from policy formulation to implementation faces challenges such as bureaucratic hurdles, competing interests, and resource limitations. Practice becomes crucial here, involving efforts to translate policies into tangible actions that engage communities and adapt to local contexts.

Hence, successful bridging requires active collaboration among researchers, policymakers, practitioners, and the public. Equity, diversity, and inclusion are vital, ensuring policies and practices address the needs of communities, particularly in developing settings. Rigorous efforts are needed to bridge the gap between research, policy, and practice in the developing world. This interdisciplinary approach holds the key to making meaningful differences in individuals' and communities' lives.

Members of the Presentation Evaluation Panel

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List of Abstracts

MATHEMATICS

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INVESTIGATION OF ANTI-INFLAMMATORY EFFECT OF SELECTED PLANT EXTRACTS AGAINST *Escherichia coli* INDUCED SEPTIC SHOCK IN ZEBRAFISH MODEL

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Inflammation is initiated by the immune system in response to various adverse stimuli, such as infections, cellular damage, etc., protecting the host by recognizing and responding to these intrinsic and extrinsic factors by eliminating them and activating sophisticated and finely tuned mechanisms. Anti-inflammatory drugs are widely used to reduce inflammation though they have many harmful side effects. This study focused on evaluating the anti-inflammatory potential of Cinnamon *(Cinnamomum verum)*, Red sandalwood *(Pterocarpus santalinus)*, and Black pepper *(Piper nigrum)* extracts against *Escherichia coli*-induced inflammation in zebrafish larvae. Cold maceration with ethanol followed by concentration and freeze-drying were used to prepare the extracts. The highest concentration of each extract with no toxicity to zebrafish larvae which can be used as a drug in the drug screening study was determined. These concentrations were as follows; cinnamon- 20 µg/mL, pepper- 1000pg/mL, red sandalwood- 50 µg/mL, and stock solutions were prepared at these concentrations. Then Zebrafish larvae were exposed to a dilution series of stock solutions of herbal extracts as test material and 10^8 CFU/mL *E. coli* as an inflammatory agent with proper controls. Biomarker analysis included malformations, heartbeat, and macrophage migration assessment. *E. coli* infection significantly triggered inflammatory responses in zebrafish larvae, leading to septic shock-induced mortality. Malformations that were observed are necrotic yolk, bent spine, and swollen pericardial sac. Notably, the plant extracts, black pepper, and cinnamon significantly reduced the *E. coli* -induced inflammation. *E. coli* treatment increased the heart rate up to 263.00 ± 16.21 compared to the untreated control (161.80 ± 2.95). Posttreatment with black pepper 1000pg/mL and cinnamon 20 µg/mL reduced the *E. coli*-induced heart rate to 165.50±2.41 and 162.20±5.26, respectively. Neutral Red *E coli* treatment increased the NR accumulation up to 111.43 ± 1.66% compared to the untreated control (100 ± 4.14%). Posttreatment with black pepper and cinnamon reduced the *E. coli*-induced NR accumulation to 97.70±0.87 and 115.02±2.53, respectively. The highest concentration of cinnamon (20 µg/mL) and black pepper (1000 pg/mL) completely restored the normal phenotype. These findings highlight the potential of zebrafish as a rapid drug screening model, especially in evaluating plant-based anti-inflammatory interventions, and suggest the therapeutic promise of plant extracts in alleviating inflammation. Due to time constraints, we were unable to complete the experiment on Red Sandalwood. However, the data collected thus far is promising and warrants further investigation.

Keywords: *Anti-inflammatory drugs, Animal model, Drug screening model, Escherichia coli-induced inflammation, Macrophage migration*

ISOLATION AND CHARACTERIZATION OF THERMOPHILIC BACTERIA FROM GOMARANKADAWALA AND KANNIYA HOT WATER SPRINGS IN SRI LANKA FOR FUTURE BIOTECHNOLOGICAL APPLICATIONS

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Industrial processes often take place under harsh conditions that are hostile to microorganisms and their biocatalysts. So, microorganisms that grow and survive at higher temperatures like 50 ^{0}C or above are biotechnical treasures for high-temperature bioprocessing due to their thermo-stable biocatalysts/thermozymes. In Sri Lanka, there are only very limited studies on the thermophilic bacteria. So, the purpose of this study is to isolate and characterize thermophilic bacteria from two selected hot springs, *Gomarankadawala* and *Kanniya* Springs in Sri Lanka for future biotechnological applications. To achieve this, first, all the bacterial strains in the water samples were cultured on Nutrient agar media and incubated at a moderate temperature (40 ^{0}C). Then, the isolates were subcultured and incubated at 50 ^{0}C to isolate thermophiles. From the 85 bacterial isolates, 7 isolates were grown above 50 ^{0}C. To confirm them as thermophiles or thermotolerants, a temperature assay was conducted. Isolate GI 60 was able to grow up to 70 ^{0}C and isolate KI 15 was able to grow up to 65 ^{0}C. For morphological characterization, colony characters such as the size, colour, shape, margin, elevation, pigmentation, texture, opacity and the surface appearance of the colonies were observed. Then, Gram's staining and motility test were done. All seven isolates were gram-positive bacteria. Except GI 39 which was a diplococcus, all other bacteria were bacilli. KI 3 was motile and all others were non-motile. Biochemical tests such as oxidase, catalase, urease, citrate, indole, methyl red (MR), Voges-Proskauer (VP) and triple sugar iron tests were done. Further, the ability to produce protease, amylase, cellulase and lipase enzymes was tested. All 7 isolates were indole positive, urease positive and MR positive whereas VP negative and oxidase negative. Only GI 34 and GI 39 were catalase positive. Isolates KI 3, GI 16, GI 39 and GI 60 were citrate positive. At 50 ^{0}C, protease and amylase enzymes were produced by GI 60. And at 50 ^{0}C, amylase was produced by GI 16 and KI 3. This indicates that these bacteria and their enzymes can be used for future biotechnological applications.

Keywords: *Thermophilic, Kanniya, Gomarankadawala, Hot springs, Enzymes.*

Acknowledgements: This work was supported by the Fungal Biotechnology Project conducted in collaboration with the Department of Plant Sciences, University of Colombo which has been funded by the ADB (Asian Development Bank).

DEVELOPMENT AND QUALITY ASSURANCE OF A PROBIOTIC CEREAL BAR

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Probiotic-incorporated cereal bars offer a convenient and nutritious option for delivering beneficial microorganisms to consumers of all ages. This study presents a cereal bar composed mainly of rice, corn, and oats, with free and microencapsulated probiotics incorporated within a chocolate coating, as an attractive method for probiotics delivery. A mixed culture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* was utilized as probiotics. Two methods, extrusion and emulsion were employed for probiotic microencapsulation. The encapsulation efficiency of the extrusion method was 73.64±0.69%, while the emulsion method achieved 84.11±0.86%. Microbial load after freeze-drying did not significantly differ between the two methods. Microencapsulation notably enhanced the survival of probiotic cells under simulated gastrointestinal pH conditions, compared to free probiotics. Four cereal bar types; without probiotics (CB1), with free probiotics (CB2), with probiotics encapsulated through extrusion (CB3), and emulsion (CB4) were evaluated for nutritional composition, and also for probiotic viability and shelf stability in three storages; room temperature (S1), refrigerator (S2), and freezer (S3) for 21 days. Without a significant difference among cereal bar types, they contained commendable nutrient levels including moderate fat (8-10%) and high crude fiber (9-10%) content. Statistical analysis revealed that the cereal bar type, storage condition, and storage duration individually and interactively affected viable probiotic cell count and yeast and mold counts. S1 exhibited a significantly high reduction of viable probiotic cell count compared to S2 and S3. The reduction of viable free probiotics number was significantly higher than microencapsulated probiotics in all three storages. CB3 and CB4 retained more viable probiotic cells in S2 and S3, but CB2 has reduced lower than 10^6 CFU g^{-1}. Yeast and mold growth peaked in S1 at 21 days but was not reported in S2 and S3. *Escherichia coli* was not reported in cereal bars in any storage condition during the time. This research highlights that microencapsulation increases the survival of viable probiotic cells in gastrointestinal pH and also extends the probiotic viability for 21 days in refrigerator or freezer storage compared to room temperature. Further investigations into controlling yeast and mold growth can extend the shelf life of the cereal bars.

Keywords: *Probiotic-incorporated foods, Cereal bar, Chocolate coating, Microencapsulation, Gastrointestinal tract simulation*

THE IMPACT OF SOME BACTERIAL AND FUNGAL BIO-FERTILIZERS ON THE ROOT ENDOPHYTIC FUNGAL POPULATION AND GROWTH OF RICE (*Oryza sativa* L.)

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Rice (*Oryza sativa* L.) is the most crucial staple food crop in Asia. However, extensive use of chemical fertilizers has led to the collapse of sustainability in rice cultivation, a decline in soil microorganisms, and significant challenges in food safety. Therefore, this study was carried out to investigate the effects of the nitrogen-fixing *Azospirillum* spp. and phosphorus-solubilizing bacteria, *Pseudomonas* spp., *Bacillus* spp. as well as *Trichoderma* spp. based biofertilizer application, on the endophytic fungal population and growth of rice. A pot experiment was conducted to assess the effects of biofertilizers on endophytic fungal population, and the growth and yield of rice. The fungal endophytes isolated from the six treatments (T1- Normal soil, T2- With Nitrogen fixing *Azospirilum* spp., T3- With Phosphorus solubilizing *Pseudomonas* spp., *Bacillus* spp. + Rock phosphate, T4- *Trichoderma* spp., T5- With *Azospirilum* spp. + *Pseudomonas* spp., *Bacillus* spp. + *Trichoderma* spp. + Rock phosphate, T6- With recommended inorganic fertilizer) belonged to common genera found in soil, including *Aspergillus flavus, Aspergillus niger*, two other *Aspergillus* spp., *Penicillium* spp., *Fusarium* spp., *Trichoderma* spp., and *Bipolaris* spp. The discovery of numerous potential plant pathogenic genera as endophytes supports the idea that they can be considered as latent pathogens. The statistical analysis revealed no significant difference in the diversity and abundance of root endophytes among the treatments ($p>0.05$). Nevertheless, the control and the treatments showed significant differences ($p<0.05$) in biometric parameters such as shoot length, root length, number of tillers per plant, flag leaf length, dry biomass, 100 grain weight, number of grains per panicle and harvest index. All the data were statistically analyzed using one-way ANOVA and the Tukey pairwise comparison test. Also, there were significant differences in soil nitrogen and phosphorus levels, soil pH and conductivity among the treatments. Although the biofertilizes used did not alter the rice root endophytes, it significantly increased the growth and yield of rice plants similar to the inorganic fertilizer added treatment. Therefore, the development and effective use of such biofertilizers could be considered a sustainable alternative for reducing the demand of synthetic chemical fertilizers in rice cultivation in Sri Lanka.

Keywords: *Sustainability, Endophytes, Growth & yield parameters, Rice*

EVALUATION OF CHEMICAL COMPOSITION AND ANTIBIOTIC ACTIVITY OF SELECTED LICHEN SPECIES FROM MIHINTALE, SRI LANKA AGAINST FOOD-BORNE PATHOGENIC BACTERIA

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The indiscriminate use of antibiotics causes bacteria to develop drug resistance. The discovery of new compounds to challenge drug resistance is critically important. Lichen's far-developed efficient mechanisms largely depend on the products of chemical compounds against microbial pathogens. Therefore, they have been used in traditional medicine including Ayurveda in the treatment of wounds and skin disorders. The present study was conducted to investigate the chemical composition and the antibacterial activity of hexane, methanol, dichloromethane and aqueous extracts of four different lichens, namely *Lepraria* sp., *Parmotrema* sp., *Ramalina* sp., and *Dirinaria* sp., collected from Mihintale, Sri Lanka, against foodborne pathogenic bacteria including *Escherichia coli, Staphylococcus aureus* and *Enterococcus faecalis*. Lichens were identified using their morphological, anatomical, and chemical characteristics. Bacterial susceptibility was tested using a standard disc diffusion assay using hexane, methanol, dichloromethane, and aqueous extracts of four lichens against *E. coli, S. aureus,* and *E. faecalis.* Minimum inhibitory concentration (MIC) was determined by a broth microdilution method using 96 well plates. Vancomycin and ampicillin were used as the positive controls in both tests. Thin layer chromatography (TLC), thalline spot test, and TLC bioautography test were performed to determine the chemical composition and bioactive compounds of the four lichens. Methanolic extract of *Ramalina* sp. showed the highest activity against *S. aureus* with the MIC of 0.625 mg/mL. Only *Lepraria* sp., and *Parmotrema* sp. were active against *E. coli.* Bioactive compounds of lichen species were observed after visualizing the TLC plate and after carrying out the bioautography test against *S. aureus*. Atranorin, salazinic acid, and usnic acid were among the secondary metabolites identified by the TLC and spot test reactions. Atranorin and two other unknown compounds were identified as bioactive compounds after carrying out the bioautography test against *S. aureus*. In conclusion, all lichens represent potentially important sources of future antimicrobial drugs. Further investigation of the methanol extract of *Parmotrema* sp. and *Ramalina* sp. will enable us to determine the most active compounds for the activity and their mechanism of action against bacterial pathogens, and also their cytotoxicity against normal cells.

Keywords**:** *Lichen metabolites, Bioactive compounds, Drug resistance, Antimicrobial property, TLC bioautography*

EVALUATION OF ENTOMOPATHOGENIC FUNGI IN BIOCONTROL OF SMALL HIVE BEETLE (*Aethina tumida)*

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Small hive beetle (SHB) is considered a scavenger and parasite of honey bees and their colonies especially outside of its native habitats. SHB larvae consume honeybee eggs, brood, pollen, and honey, causing highest destruction. When colonies are highly infected, bees abandon the colony, leaving the honey and their brood behind. To control the SHB, usage of chemical pesticide is very common. But emergence of pesticide resistance varieties, effect on those chemical to the bees and human health lead to investigate other methods of control for SHB. Therefore, there is a positive trend to investigate eco-friendly biological control methods. SHB has been recorded very recently in Kegalle, Sri Lanka, and there is a need to investigate a good biological controlling method to control SHB in Sri Lankan context. Therefore, this research aim is to evaluate fungi species as potential entomopathogenic fungi for the beetle as potential biological control agents. Several fungal species were isolated and tested on the adult SHB and their larval stages. Entomopathogenic fungi species were isolated using two methods: 1. insect bait method to isolate soil fungi using greater wax moth larvae as the bait and 2. Natural insect cadavers with visible mycosis. In the bait method to prevent excessive webbing larvae were heat treated and placed on soil. Visibly mycosis larvae cadavers and collected natural insect cadavers were placed on PDA containing amoxicillin. Isolated fungi were tested with adult and larval SHB. Treatment groups were tested with 10^8 spore solution that adjusted using heamocytometer and the control group was tested with distilled water. Fungal species 1 and 2 had shown 100% mortality in adult SBH in eight days. All the five fungal species had shown mortality in wandering larvae of SBH thus four isolated fungal species had shown 100% mortality in that species 1 and 2 showed 100% mortality from 48 hours. To control the larvae and adult SBH fungal species 1 and 2 are promising but need further investigation in field trials and effect on non-target organisms. This research contributes valuable insights into the biocontrol potential of entomopathogenic fungi against SBH, highlighting the importance of native strains used as biological control agents.

Keywords: *Honeybees, Invasive species, Pest management, Natural pathogenic agents*

IN-VITRO SCREENING OF *Punica granatum* BREEDING LINES FOR ANTHRACNOSE DISEASE RESISTANCE BY DETACHED LEAF INOCULATION TECHNIQUE

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Punica granatum, commonly known as the pomegranate, holds a distinguished status in botanical circles owing to its rich history, diverse uses, and remarkable nutritional profile. This scientific discourse investigates the resistance exhibited by novel pomegranate lines against anthracnose disease, with the overarching goal of establishing a foundation for the development of anthracnose-resistant pomegranate varieties in the future. Anthracnose is a fungal disease that can affect pomegranate trees, caused by various species of the *Colletotrichum* genus, notably *Colletotrichum gloeosporioides*. Primary inoculum is disseminated by wind or rain infects the host using diverse strategies and causes biotrophic and necrotrophic infections. It can lead to significant economic losses in pomegranate orchards by causing fruit rot, premature fruit drop, and decreased yield. Different strategies can be identified to minimize the pathogen infection. As a solution, resistant varieties play a crucial role in sustainable agriculture by reducing the need for chemical pesticides and fungicides, minimizing environmental pollution, and promoting ecosystem health. In this study, highly resistant and moderately resistant lines and susceptible lines to anthracnose disease were distinguished using a detached leaf inoculation technique. Both the drop method and the disc method were utilized for leaf inoculation. Of these, the drop method involves the inoculation of leaves with a spore suspension of *Colletotrichum*, offering a setting that closely mimics natural conditions for assessing line resistance. Based on the outcomes of both the drop and disc methods, TC11, 67, and 78 lines can confidently be identified as highly resistant lines, 46 and A1 lines can be identified as moderately resistant and A2 line can be identified as susceptible line to anthracnose based on the results obtained from the drop method other than lines Kalpitiya hybrid can be identified as susceptible variety and Nimali and Daya can be identified as highly resistant varieties to anthracnose based on the results obtained from the drop method.

Keywords: *Pomegranate, Colletotrichum, Resistant varieties, Breeding lines, Fungicide*

Acknowledgments: The authors are grateful to Dr Vindya Basnayake, deputy director of the Plant Virus Indexing Center, Homagama, for permitting me to carry out my research at Plant Virus Indexing Center.

FURTHER INVESTIGATION INTO THE MOLECULAR PHYLOGENETICS OF THE SRI LANKAN LAND-SNAIL GENUS *Corilla*

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The genus *Corilla* is a land-snail genus endemic to Sri Lanka and India's Western Ghats. In Sri Lanka it is represented by 10 extant species, which are largely forest-living. This thesis investigates the molecular phylogenetics and taxonomy of Sri Lankan *Corilla*, focusing on the phylogenetic placement of two previously unsampled populations, one a population of *Corilla erronea* var. *erronella* and the other a population tentatively identified as *Corilla carabinata*. Our dataset includes nine nominal Sri Lankan species and is based on two mitochondrial genes (CO1 and 16S rRNA). While the deeper nodes in the trees were not fully resolved, we found that our population of *C. erronea* var. *erronella* does not group with any of the other species or populations in the phylogeny, suggesting that this may be a distinct species. This, however, needs further study. We also found that the second of the previously unsampled populations grouped with *C. carabinata*, confirming that this population is indeed *C. carabinata*. The other patterns in our molecular phylogeny are consistent with the work published to date, but a species delimitation analysis showed that the number of species of Sri Lankan *Corilla* is higher than what is currently known. This has obvious implications for the conservation of this endemic and threatened genus and clearly needs further, detailed study.

Keywords: *Corilla, Land-snail, Sri Lanka, Phylogeny, Taxonomy*

SOCIAL BEHAVIOUR OF *Semnopithecus vetulus* IN HETEROSPECIFIC AND CONSPECFIC GROUPS

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Polyspecific associations can lead to hybridization between species. While hybridization has been reported in polyspecific colobine monkey species, the interaction between conspecifics and heterospecific males is poorly understood. This study investigates the social behavior of *Semnopithecus vetulus* in conspecific and heterospecific groups, focusing on interactions between female purple-faced langurs with both conspecific and heterospecific gray langur males. Focal animal sampling was conducted on two purple-faced langur groups, one of which was polyspecific at the Kaludiyapokuna Forest Reserve from October 2023 to December 2023. Specifically, interactions between males and female, purple-faced langurs, as well as interactions between a purple-faced langur male and a gray langur male, were recorded. Grooming behaviors revealed significant preferences among males and females, with the gray langur male exhibiting pro-social grooming behavior towards female purple-faced langurs. Females in the heterospecific group displayed grooming preference, with only one female purple-faced langur interacting with both males. Vocalization patterns varied, with higher territorial call frequencies observed in conspecific groups compared to heterospecific group, possibly in response to social disruption caused by the presence of a heterospecific male. Instances of aggression were higher in the heterospecific group particularly between the conspecific and heterospecific male. Aggression was also directed towards an estrus female, which was followed by both the conspecific and heterospecific male. Mating was observed only between conspecifics. Mating behaviors showcased complex interactions, with females displaying mate preference and intricate reproductive strategies. The results of this study suggests that the integration of heterospecific males into purple faced groups, can cause "social disruption" where the interaction between conspecifics is disrupted.

Keywords*: Semnopithecus vetulus, Heterospecific groups, Grooming, Conspecific groups, Mating behaviour*

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EXPLORING RESOURCE PARTITIONING AMONG AVIFAUNA IN DAMBULLA KALUDIYAPOKUNA FOREST

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Kaludiya Pokuna Forest Reserve (KFR), a 13 km^2 area of semi-evergreen forest located in the Matale District, Central Sri Lanka which is characterized by minimal human disturbance. This study marks the first comprehensive investigation into the Kalidiyapokuna forest, addressing the notable gap in research on resource partitioning among avifauna in Sri Lanka and underlining the importance of understanding these dynamics for effective conservation and management strategies. Initial surveys led to the selection of three distinct sites, with field observations conducted from October to December 2023. Data Were gathered by direct field observation based on focal sampling method to observed resource partitioning (habitat, food, time) and niche overlapping behaviors. Field observations were carried out from 7.30am to 5.30pm (active times) within the selected locations by direct or with the aid of a Pentax 8 x 40 binocular. Utilizing the iNEXT 4steps method, the gathered data were analyzed to uncover insights into avian diversity and resource utilization patterns. The study reveals a remarkable richness of avian species, with 96 species identified across 51 families, including eight endemic species, establishing the region as a rich avifaunal hotspot. The study's findings indicate significant variations among avifauna concerning time, habitat, vertical distribution, and diverse food preferences. Monthly variations in species counts across habitats highlight dynamic patterns, with the aquatic habitat consistently supporting the highest species count. The findings suggest that ongoing observations and investigations are crucial for discovering rare or unidentified species. Vertical distribution analysis within the canopy, ground, and sub-canopy reveals specific patterns in species richness and diversity, indicating niche specialization within each stratum. Diurnal variations highlighted distinct species compositions during morning and evening periods, indicative of avian adaptability to different times of the day.Feeding category analysis revealed a prevalence of insectivorous birds, underlining their reliance on insects as a primary food source, while the presence of omnivorous species emphasized the importance of habitat heterogeneity in supporting diverse feeding habits. The research provides valuable insights into avifaunal diversity and resource partitioning dynamics in the Dambulla Kaludiya Pokuna Forest Reserve, emphasizing the need for ongoing monitoring and conservation efforts to preserve this crucial environment.

Keywords: *Resource partition, Avifauna, Species Richness, Avifaunal diversity, Niche overlapping*

CHEMISTRY

PHYTOCHEMICAL PROFILING AND BIOCHEMICAL ACTIVITIES OF *Diplodiscus verrucosus* AND *Dimorphocalyx glabellus*

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Medicinal plants provide crucial natural products for pharmaceutical research, serving as valuable sourcesof therapeutic agents. Both *Diplodiscus verrucosus* and *Dimorphocalyx glabellus*, plants are endemic to SriLanka and belong to Malvaceae and Euphorbiaceae families, respectively. Despite their endemic status,there is a lack of information within Ayurveda medicine for both species. The objectiveof this study is to investigate the biochemical activities and conduct preliminary phytochemical profiling in combination with methanolic and dichloromethane extraction of leaves, bark, and roots from both plants. An antioxidant assay conducted using DPPH (2,2- Diphenyl-1-picrylhydrazyl) free radical scavenging method revealed significant antioxidant activity in *D. verrucosus* leaves, and *D. glabellus* roots exhibited the highest activity compared to Ascorbic acid as the standard. All samples from *D. verrucosus* showed a lower IC50 value than *D. glabellus.* In the antimicrobialassay, *D. verrucosus* demonstrated maximum antibacterial activity against *Staphylococcus aureus*, while *D. glabellus* exhibited the highest activity against *E. coli*. Both showed higher zones of inhibition against *Candida sp*. Root extracts contained higher zones against *Candida albicans* compared to Fluconazole. The pesticidal activity of *D. verrucosus* against pest *Sitophilus oryzae* was assessed using repellence bioassays. The results demonstrated 76% repellency after 24 hours for the 10,000 ppm plant extracts. Phytochemical screening indicated the presence of Alkaloids, Flavonoids, Phenols, Steroids, and Tannins in both plants. Gas Chromatography-Mass Spectrometry (GC-MS) analysis identified a total 83 compounds in *D.verrucosus*, including β- Caryophyllene (7.09%), Germacrene (0.99%), Humulene (2.29%), Linalool (0.37%), Neophytodiene (1.14%), and *D. glabellus* revealed 78 compounds with significant concentrations of Squalene (1.44%), Phytol (4.64%), Neophytodien (6.51%), Hexadecenoic acid (12.57%), Tocopherol (8.89%), and Stigmasterol (2.28%). The finding revealed some significant components such as β-Caryophyllene, Germacrene, and Humulene that are already recorded to have pesticidal properties. The research concludes that both plants demonstrated promising herbal properties. However, *Diplodiscus verrucosus* showed superior performance in antioxidant, pesticide, and antimicrobial activities compared to *Dimorphocalyx glabellus*. The finding emphasizes the significance of endemic plant species, particularly highlighting the pivotal role of *D. verrucosus*. This endemic species showed a potential for pesticidal effectiveness.

Keywords: *GC-MS, Antioxidant, DPPH, Insecticides, Anti-microbial, Sitophilus oryzae, Phytochemicals*

STUDY AND FORMULATION OF STARCH-CELLULOSE ACETATE BIODEGRADABLE POLYMER COMPOSITE

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Synthetic plastic's long lifespan and reliance on nonrenewable resources lead to garbage disposal and pollution. In recent years, there has been an increase in interest in biodegradable polymers, which can be classified into synthetic and natural polymers. Polymers can be produced from petroleum resources (non-renewable) or biological resources (renewable). This study describes the synthesis of totally biodegradable polymer composites from natural materials using cassava starch and cellulose acetate. Starch is a cost-effective, renewable, and biodegradable biopolymer that can be used in biocomposite materials. Starch itself, exhibits poor mechanical properties such as low tensile strength and severe deformations, which limits its application in biodegradable polymers. Reinforcing the starch matrix using biodegradable reinforcements, such as cellulose fibers, may resolve these limitations and create cost-effective starch biocomposites. A derivative version of cellulose called cellulose acetate was used combined with starch to make the biodegradable composite. Cellulose acetate is commonly used in creating photographic film, fiber, membranes, and bioplastics. Polymers were created using glycerol as the plasticizer. The biodegradability, water solubility, water absorption capacity, and tensile strength properties of those polymer films were determined. Pure starch-based films have a higher water absorption ability and with increasing the percentage of cellulose acetate the water absorption ability decreases. The addition of the cellulose acetate fibers increases the tensile strength due to the interfacial adhesion and the strong interaction between starch and cellulose acetate. When increasing the starch percentage biodegradability and the tensile strength were decreased. Also, when the cellulose acetate fiber content increases, water absorptivity decreases and the biodegradability and tensile strength increases.

Keywords: *Biodegradable, Biocomposite, Acetate cellulose*

STARCH-BASED POLYMER COMPOSITES USING TEAK WOOD DUST AND COCOA HUSK POWDER AS REINFORCED FILLERS

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The modern world is looking for sustainable and environmentally friendly materials instead of using synthetic plastics due to their lack of degrading properties that harm the environment. Therefore, the use of biodegradable polymers in production and everyday use is rapidly expanding. Among the most potential raw materials for the synthesis of biopolymers is starch, a polysaccharide that is cost-effective, readily available, and renewable. Both non-edible (*Mangifera indica* seed kernel starch) and edible starch sources (*Manihot esculenta*) were utilized as raw materials. Mango seed kernel starch and cocoa husk powder polymer composites were prepared with different compositions. Cocoa husk powder, biochemically comprised of lignin, cellulose, hemicellulose, and pectin and used as reinforcement filler in the polymer matrix, improving the mechanical properties such as tensile strength, and biodegradability of the polymer composite. Edible starch-based polymer composites also were prepared with different compositions using Cassava starch and chemically treated wood dust. Wood dust was used as reinforced filler in polymer composite which was chemically comprised of cellulose, hemicellulose, and lignin. The incorporation of treated wood dust enhanced the strength, biodegradability, and water absorption capacity. These polymer composites were prepared using starch, glycerol, acetic acid, and water. Glycerol used as a plasticizer and acetic acid involved in the hydrolysis of starch. These starch-based polymer composites were tested for tensile strength, water solubility, water absorption capacity, dry matter density, and moisture content.

Keywords: *Starch, Wood Dust, Plasticizer, Filler*

OPTIMIZING ELECTROCOAGULATION PROCESSES THROUGH VARIABLE FREQUENCY AC CURRENT AND ELECTRODE CONFIGURATIONS

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Electrocoagulation (EC) can be defined as the electrochemical involvement of waste water treatment and an eco-friendly approach. In the traditional approach, direct current was employed to produce coagulants, polymetallic hydroxide species, by electrodissolution of metal electrodes such as aluminium (Al) and iron (Fe). Compared to other waste water treatment processes, the EC is a cost-effective method. However, the traditional electrocoagulation process that was conducted with direct current (DC) associates with certain drawbacks such as deposition of non-conducting material on the anode and passivation limits. The application of alternative current (AC) has been found to be a highly effective method to overcome the drawbacks of DCEC, and minimizes the higher electrode dissolution and minimize nonconducting material deposition by alternating the polarity of electrodes. In this study, current density, applied potential, frequency of current, initial pH, initial conductivity of electrolyte, temperature, operational time, electrolyte composition, electrode material, and configuration were studied for efficient removal of Ca and Mg in water. It was found that, the final pH of treated water depends on the initial composition of the electrolyte in the wastewater. Under optimal conditions of 14.00 volts, 300 Hz AC, and 90 minutes, with Al-Al electrode system, a removal of 80% Ca^{2+} and 70% of Mg^{2+} were achieved. EC carried out for 1000 µS/cm Na_2SO_4 and 1000 µS/cm $CaCl_2 + Mg(NO_3)_2$ solutions, the final pH value reached approximately to 10.04, with the Na_2SO_4 electrolyte and 8.34 with the $CaCl_2 + Mg(NO_3)_2$ electrolyte. For other Al-Fe, and Fe-Fe electrode configurations, different efficiencies were investigated.

Keywords: *Electrocoagulation, Electodissolution, Polymetallic hydroxide, Coagulants, Alternative current*

ZIRCON ($ZrSiO_4$) MODIFIED POLYANILINE COMPOSITE FOR ALUMINIUM REMOVAL IN WATER

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Efficient removal of aluminum (Al^{3+}) from drinking water is imperative due to its detrimental effects and environmental implications. Current methods are often costly and lack reusability. This study introduces a novel approach using a Zircon-Polyaniline ($ZrSiO_4$/PANI) composite for the effective removal of aluminum ions. The composite was synthesized through an oxidative polymerization of aniline onto the $ZrSiO_4$ surface. Characterization via Scanning Electron Microscopy (SEM), Fourier Transform Infrared (FTIR), and Cyclic Voltammetry (CV) revealed the composite's structural and electrochemical properties. Surface of the composite appeared aggregated with increased surface area and adsorption of aluminium onto the composite surface was confirmed with 6.6% of aluminium exhibited in SEM elemental analysis. Redox peaks appeared in cyclic voltammetry of zircon at pH 3.0 on glassy carbon electrode suggests the presence of iron impurity in zircon. Batch experiments conducted under optimal pH of 5 for a 50 mL 100 ppm Al^{3+} solution containing 30 mg of $ZrSiO_4$/PANI composite followed by Inductively Coupled Plasma Mass Spectrometry (ICPMS) analysis showed a removal efficiency of 98.9% within 30 minutes. Statistical analysis and optimization were accomplished using Response Surface Methodology (RSM). The thermodynamics of adsorption were studied and ΔH (change in enthalpy), ΔS (change in entropy) and ΔG (change in Gibbs free energy) were found to be 450.33 kJ mol^{-1}, 176.55 J mol^{-1} K^{-1} respectively. The negative values of ΔG at all three temperatures 15°C, 25°C, and 35°C were -5.75 kJ mol^{-1}, -7.46 kJ mol^{-1}, and -8.67 kJ mol^{-1} respectively, elucidate the spontaneous nature of the adsorption process. The adsorption kinetics were well-described by a pseudo-second-order model, while the Freundlich and Temkin isotherm models proved to be the most fitting. This research not only introduces an efficient and reusable method for aluminum removal but also provides valuable insights into the adsorption mechanism.

Keywords: *Aluminium, Polyaniline, Zircon, Adsorption, Composite*

PHYSIOCHEMICAL PROPETIES OF CROSS-LINKED CASSAVA STARCH POLYMER WITH TRISODIUM PHOSPHATE

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Recently, the manufacture of natural biodegradable polymers from natural sources has emerged as a significant research topic. The same durability properties that make plastics ideal for many applications, such as packaging, building materials and commodities, as well as hygiene products, can lead to waste disposal issues in the case of traditional petroleum-derived plastics. These materials are not easily biodegradable and accumulate in the environment due to their resistance to microbial degradation. One of the most promising raw materials for the creation of biodegradable polymers is starch, a natural renewable polysaccharide found in a number of crops. Chemical treatments involve the introduction of suitable functional groups into the starch molecule via derivatization reactions such as etherification, esterification, crosslinking, and grafting, or decomposition reactions such as acid or enzymatic hydrolysis. Chemical modification is commonly used to improve the properties of starch in order to meet the requirements of particular applications. Crosslinking is one of the most often used strategies to alter starch. It is intended to add intra- and inter-molecular links at random places of a starch molecule. Glycerol acts as a plasticizer, and when added to polymer synthesis, it can improve the flexibility, elasticity, and handling properties of the polymers produced. Acetic acid was commonly added to starch to aid in the breakdown of branched amylopectin molecules into straight chain amylose molecules. This study investigated the effects of trisodium phosphate cross-linking on cassava starches' structural, adsorptive, water solubility, biodegradability, and tensile strength properties. The proportions of glycerol, trisodium phosphate, and acetic acid were changed from 10% to 50%. The optimization results indicate that a biodegradable polymer composed of 20% trisodium phosphate, 20% glycerol, and acetic acid has the maximum tensile strength. The optimal biodegradable polymer had 20% tri sodium phosphate, 20% glycerol, and acetic acid.

Keywords: *Biodegradable polymers, Cross-linking, Trisodium phosphate*

EXPLORING THE BIOACTIVITY, CHEMICAL PROFILING AND THE ASSESSMENT OF TRACE METAL CONTAMINATION IN MARINE SPONGES

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Marine sponges belonging to Phylum Porifera, sessile filter-feeders are recognized as a rich source of bioactive compounds in the marine environment with promising biological activities due to their diverse primary and secondary chemical components. The marine sponges serve as an excellent bioindicators of environment health, significantly in the context of trace metal contamination to detect the toxicity of the environment. The current study was aimed to evaluate the bioactivity, chemical composition and to assess the trace metal contamination of the marine sponges. Ten samples were collected by scuba diving from sea-off Kalmunei in East Coast of Sri Lanka and extracted into methanol and dichloromethane. Antioxidant assay was conducted using DPPH free radical scavenging method and the antimicrobial assay was determined by disc diffusion method. Antibacterial activity was tested against *Escherichia coli* and *Staphylococcus aureus*, while antifungal activity was tested against *Candida albicans* and *Candida spp.* Ampicillin and Flucanazole were used as the positive control for bacteria and fungi respectively. Gas Chromatography – Mass Spectrometry (GC-MS) was used to determine the chemical composition profile. Trace metal contamination was quantitatively analyzed using Inductively Coupled Plasma - Mass Spectrometry (ICP-MS). Samples K9 and K2 showed the highest and the lowest antioxidant activity respectively. The inhibition zone against *Escherichia coli* and *Staphylococcus aureus* were highest in the sample K9, while Candida *albicans* and *Candida spp*. showed higher inhibition zone in sample K7. Phytochemical screening discovered alkaloids, sterols, tannins, saponins and terpenoids. GC-MS analysis identified a total of 115 different compounds where Naphthalene, Thunbergol, 2,4-Di-tert-butylphenol, n-Hexadecanoic acid, Octadecanoic acid, Squalene, ɤ-sitosterol, Stigmasterol, Neophytadiene, 1-Heptatriacotanol, Heneicosane, Caryophyllene, Hexadecanoic acid methyl ester and 1-Eicosanol were the major compounds. The highest trace metal concentration of Arsenic, Cadmium, Lead and Mercury were 151918.60 µg/kg (K1), 2183.21 µg/kg (K6), 957.12 µg/kg (K9) and 200.54 µg/kg (K9) respectively. The overall study confirms that the marine sponges from the study site contain an extensive range of bioactive compounds with remarkable bioactivities. However, it also indicates that the study site has been contaminated with some trace metals and marine sponges serve as a critical tool for environmental monitoring and conservation.

Keywords: *Marine sponges, Antioxidant, Antimicrobial, Phytochemical screening, GC-MS, Trace metals, ICP-MS*

ISOLATION AND CHARACTERISATION OF DISSOLVED ORGANIC CARBON IN THURUWILA WATER

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Thuruwila is a 750-acre, historic irrigation reservoir in the Anuradhapura region. It has a 2.4 km long bund that is 180 feet wide, 25 feet tall, and has a mean depth of 12.5 feet. At full capacity, Thuruwila supports the local community and is an essential source of water for Anuradhapura Town. Dissolved Organic Carbon (DOC) fractions in water has been a pressing issue since it causes membrane fouling results in decreasing the efficiency and life time of drinking water treatment plants such as Reverse Osmosis (RO) and Electro Dialysis Reversal (EDR). In this study, 200 liters of water from Thuruwila reservoir were treated through Superlite DAX-8 resin followed by extraction using NaOH, concentration, and purification. Following the extraction procedure, it was found that the sample contained 3.3698 g of fulvic acid (FA) and 0.4390 g of humic acid (HA). The process's selected approach was customized according to the specifications of the water sample and the particular kinds of organic carbon that are of interest. For the purpose of evaluating water quality, identifying the sources of contamination, and developing efficient water treatment plants, precise measurement of each individual DOC component is crucial. Both FA and HA showed characteristic UV-vis absorption bands at 259 nm and 345 nm respectively. FTIR spectroscopic analysis of HA from water exhibited absorption band at 3439 cm^{-1} region is attributed to O-H stretching vibrations and stretching vibration of C=C bonds in aromatic rings appeared at 1581 cm^{-1}. H-bonded OH in FA were characterized at 3415 cm^{-1}. The band at 1564 cm^{-1} is frequently linked to quinone and/or H-bonded conjugated ketones.

Keywords: *Dissolved organic carbon (DOC), Fulvic acid (FA), Humic acid (HA)*

SQUARE WAVE PULSE VOLTAMMETRY FOR THE QUANTIFICATION OF ANTIBIOTICS, CIPROFLOXACIN IN AQUEOUS MEDIUM

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Antibiotics, a crucial class of medicinal substances, are extensively employed for combating bacterial infections, a pressing concern in modern times. Square wave pulse voltammetry (SWPV) was used as an analytical tool for the precise determination of ciprofloxacin, by employing electrochemically modified SnO_2 -TiO_2 nanotubes. This method offers a reliable means of detecting and quantifying ciprofloxacin in aqueous medium. The electrode was fabricated by anodizing the titanium metal plate, forming TiO_2 nanotubes and electrodeposition SnO_2 on it. Cyclic voltammetry of ciprofloxacin at pH 6 exhibited an anodic peak at 0.1 V for the electrochemical oxidation of ciprofloxacin. SWPV analysis showed that an excellent linear dependence of the oxidative peak current at 0.1 V with respect to Ag/ AgCl electrode, in the range 1.0- 1×10^6 nM with limits of detection (LOD) of 0.2 ng/L. Bulk electrolysis of ciprofloxacin solution at 0.3 V for 2 hours resulted a yellow color solution and preparative thin layer chromatography yielded two compounds of ciprofloxacin and its oxidized form. The electro synthesized product was characterized by UV-Vis and FTIR spectroscopy. In the FTIR analysis, it was found that the disappearance of N-H bending vibration peak of ciprofloxacin in the range of 1600-1650 cm^{-1} and appearance of a new peak corresponding to the O-H functional group at 3375.15 cm^{-1} for the oxidized product of ciprofloxacin.

Keywords: *Antibiotics, Ciprofloxacin, Square wave pulse voltammetry, Electrochemically modified electrodes*

PREPARATION OF NANOCELLULOSE REINFORCED CASSAVA STARCH BASED BIODEGRADABLE POLYMER COMPOSITES

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Petroleum-based polymers contribute significantly to environmental pollution through their production, usage, and disposal, generating toxic emissions and remaining as non-biodegradable objects in ecosystems. As well as the spread of microplastics presents serious threats to human health and ecosystems, with possible outcomes including ingestion by marine life and bioaccumulation in the food chain. In order to address this problem, coordinated efforts are needed to lower plastic pollution, enhance waste management procedures, and create environmentally friendly plastic alternatives. So biodegradable polymers help minimize waste, protect ecosystems, and build a greener future. In this study, biodegradable polymer composites were prepared using Cassava starch and nanocellulose extracted from the cellulose of the invasive plant species Panicum maximum. Cellulose was extracted through alkali treatment using 6% NaOH followed by bleaching with a solution containing 1.7% NaOCl. Nanocellulose was produced via decomposing cellulose fibers in 50% concentrated sulfuric acid. This was a top-down approach. During the preparation of biodegradable polymer composites, the amounts of starch, glycerol, acetic acid, and citric acid were kept constant. Only the compositions of nanocellulose were changed to 5%, 10%, 15%, and 20%. Citric acid was used as a cross-linking reagent. Glycerol was used as a plasticizer. The water absorption capacity, water solubility capacity(at room temperature and 80°C temperature), biodegradability, moisture content , dry matter density and tensile strength of the polymer composites were determined. When increasing the amount of nanocellulose the tensile strength of the polymer composites increased due to unique properties of nanocellulose like high strength, high surface area and flexibility. Further nanocellulose was characterized using nano particle size analyzer .The dynamic light scattering results indicated that nanocellulose particle sizes were in the nanoscale range. Both cellulose and nanocellulose were characterized by UV-Visible spectrophotometer. Strong barrier properties are provided by biodegradable nanocellulose-starch based polymers, which provide sustainable packaging solutions. They are also used as mulches in agriculture, which improves soil quality and cuts down on plastic waste. They are used in tissue engineering and medication delivery in biomedicine, taking advantage of their biocompatibility and break down for regenerative purposes.

Keywords: *Biodegradable, Nanocellulose, Cassava-starch, Nano particle size analyzer, UV-visible spectrophotometer*

COMPUTING

AUTOMATED SYSTEM FOR DETECTING ROTATION RULE VIOLATION REGARDING PLAYERS' POSITION IN VOLLEYBALL

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Volleyball, a widely popular sport enjoyed by millions globally, involves a fundamental aspect known as player rotations. This study addresses the challenge of detecting rotation rule violations during live volleyball matches. With over 37 million players in the United States and 800 million worldwide, the need for an efficient system to enforce rotation rules becomes evident. The proposed comprehensive system utilizes service time images and employs a dual-pronged methodology involving player detection and jersey number extraction. The system begins by categorizing players into their respective positions front-row or back-row based on their locations on the court before the serve. This process adheres to the clockwise rotation method, ensuring consistency in positional assignment. The player detection model achieves a notable mean Average Precision (mAP) of 0.921, showcasing its efficacy in accurately identifying players on the court. Simultaneously, a dedicated model for jersey number recognition demonstrates exceptional accuracy with a mAP of 0.99. The integration of these modules results in a holistic approach to rotation rule violation detection. The combined accuracy of the integrated system reaches 85.71%, with a remarkable comparison accuracy of 90.1%, assessing the alignment of detected jersey numbers with expected values in the correct rotation. A scoring-based rotation count calculation further enhances the system's robustness and reliability. This methodology ensures a nuanced and accurate assessment of player rotations during live volleyball matches. By cross-referencing detected jersey numbers with expected values in the correct rotation, the system adeptly identifies any discrepancies, effectively flagging instances of rotation rule violations. The use of machine learning models and scoring-based rotation count calculation establishes a valuable tool for match officiation, contributing to the fair and accurate enforcement of rotation rules in volleyball.

Keywords: *Jersey number, Player detection, Rotation rule, Rule violation, Volleyball*

A NEW MACHINE LEARNING APPROACH FOR IN-GAME BEHAVIOR ANALYSIS OF FOOTBALL PLAYERS BASED ON PLAYER STATISTICS

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Recent developments in Artificial Intelligence and data analytics have brought about an evolutionary change in the football industry. The goal of this research is to improve football clubs' player evaluation and recruitment procedures by utilizing these technical advancements. The FIFA24 (Fédération Internationale de Football Association) dataset was used to collect player ratings and attributes for the study. After that, ratings of player performance were acquired from Sofascore ratings, resulting in the compilation of a single dataset. After a thorough literature study and careful data pre-processing, the dataset had been reduced to only include relevant variables for analysis. Using sophisticated machine learning techniques, the team went on to construct predictive models for player performance assessments. To train these models, a portion of the dataset was set aside. Several different methods were investigated and assessed in order to determine which combination of models was best; the voting method composite model was ultimately shown to be the best at predicting player performance ratings. Additionally, the K-means clustering technique was used to cluster players according to ratings of their qualities. The elbow approach was used to find the ideal number of clusters, and different player clusters were found according to their playing traits. Players were able to be categorized into different playing styles after a random forest model was built with a 96% accuracy rate to predict player clusters. As a result of this study, a comprehensive system that can forecast player performance ratings and group players according to their playing styles was developed. This method helps football teams and scouting teams make educated decisions about player acquisition and team composition by providing insightful data. Football teams can acquire a competitive advantage in finding players who fit them by utilizing Artificial Intelligence and data analytics, which will ultimately improve the performance and results of their teams on the field.

Keywords: *Football player analysis, Football player performance prediction, Football playing style classification, FIFA dataset analysis*

IDENTIFICATION OF NITROGEN (N), PHOSPHORUS (P), AND POTASSIUM (K) DEFICIENCIES IN RICE CROP USING IMAGE PROCESSING

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Rice is a primary food source for nearly half of the world's population. Insufficient nutrient levels can cause a decrease in crop productivity. Unidentified nutrient deficiencies prompt excessive use of pesticide and fertilizer, causing financial losses for cultivators and environmental pollution. By examining the images of rice leaves that exhibit signs of nutrient deficiencies, the specific nutrient deficiencies affecting the plants can be accurately identified. This reduces overuse of fertilizer and pesticides, improving agricultural productivity while minimizing environmental footprint. This research establishes a methodology for identifying nutrient deficiencies using ResNet50, InceptionV3, VGG19, DenseNet121, InceptionResNetV2, MobileNetV2, ResNet50V2, VGG16, and Xception Convolutional Neural Network (CNN) architectures. Initially, pre-processed data were utilized to train three CNN models by using ResNet50, InceptionV3, and VGG19 architectures, and achieved a maximum 37.5% testing accuracy with ResNet50. Subsequently, employing data augmentation techniques such as shearing, zooming, rotation, horizontal flipping, vertical flipping, and fill mode, nine CNN models were trained and achieved a 71.98% maximum testing accuracy with InceptionV3. However, due to relatively low accuracy, stratified k-fold cross validation was employed, with early stopping and model checkpoint callbacks. All nine CNN models achieved testing accuracies surpassing 90%, with the InceptionV3 architecture attaining the maximum testing accuracy at 96.03%. Upon deploying this model, a website was developed, followed by user validation, during which a total of 16 images were examined, where 12 accurately identified present deficiencies, resulting in an overall application accuracy of 75%. The accuracy of deficiency detection depends on uploaded image quality. The platform is restricted to uploading a single image in .png format. These limitations call for further development to address them, including the creation of more CNN architectures, like Support Vector Machine (SVM) and Random Forest (RF), employing advanced image processing techniques, and expanding the platform to support diverse image formats. The results demonstrate the effectiveness of stratified K-fold cross validation in improving model accuracy for small and unbalanced datasets in multiclass classification tasks. These efforts aim to enhance the usability and effectiveness of agricultural research and applications.

Keywords: *Nitrogen deficiency, Phosphorus deficiency, Potassium deficiency, Data augmentation, Stratified K-fold cross validation, CNN*

IMPROVING PERFORMANCE OF IMAGE PREPROCESSING FOR EFFICIENT IRIS RECOGNITION

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With the development of information society, biometric systems have gained significant attention in recent years for their applications in various sectors, offering reliable and secure means of personal identification. Iris recognition is considered as the most promising, accurate and robust methods of biometric authentication technology in the 21st century because of its uniqueness, stability and non-creativity. The selection of the optimal feature subset and the classification has become an important issue in the field of iris recognition. In this paper, a fast localization iris recognition algorithm is proposed, that initiates with iris image preprocessing, involving segmentation to extract the iris while eliminating artifacts. Normalization follows to standardize iris features, compensating for size and pupil variations. Feature extraction utilizes Gabor filters to capture unique textural patterns, encoding them into binary templates. The system supports user registration, storing templates and metadata in a database. Authentication involves a matching algorithm calculating Hamming distances, with a threshold mechanism to distinguish genuine from impostor matches, ensuring robust user identity validation. The system's architecture emphasizes scalability, efficiency, and user-friendliness, integrating multiprocessing for expedited processing and providing a graphical user interface for ease of interaction. This study shows that the iris recognition and authentication system demonstrate high accuracy and reliability, marking a significant contribution to the field of biometric security. Iris recognition efficiency can be improved by improving iris segmentation algorithm, and the recognition rate of iris research can be improved to a greater extent by combining with parallel processing, progress monitoring and execution timing training methods. Future work aims to explore deep learning approaches for feature extraction, cloud-based architectures for scalability, and enhanced security measures for data protection, paving the way for wider adoption in various security-conscious sectors.

Keywords**:** *Biometric authentication, Segmentation, Feature extraction, Normalization, Personal identification*

COLOR AND THEME BASED OPTIMAL OBJECT PLACING FOR BUILDING INTERIOR USING AUGMENTED REALITY

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In today's expanding and evolving world of new technologies, where discoveries are made regularly to make our lives easier, augmented reality is one of the fastest-growing sectors, with applications in practically all industries, and it will be considered one of the major technologies of the future. Augmented reality offers a unique opportunity to blend the virtual and physical worlds, allowing designers and users to visualize and manipulate virtual objects within real-world environments. In the early days, users could purchase a piece of furniture from the website, and it was hard to see how the item appeared in a particular space. And, in sometimes they were not satisfied with what they bought. As a solution for the above problem, I have proposed and developed a system that will utilize augmented reality technology to provide suggestions and assistance in placing furniture items within a building's interior space. With the help of this augmented reality concept, a user can buy furniture after viewing how it would look in the area, without physically going to a store. Considering the building's interior design, this technology provides a 3D image of the furniture items, allowing clients to interact with it and make changes in real-time. The system utilizes two convolutional neural network models, one of them for colour detection and the other one for theme detection. A collection of images was gathered and tagged with the colours and themes to train and evaluate the suggested system. These convolutional neural network models were then trained to evaluate their performances using the annotated dataset. The findings of this research work indicate that the theme detection model has a training accuracy of 99.24% and a testing accuracy of 97.06%. The colour detection model has a training accuracy of 95.23% and a testing accuracy of 99%. These accuracy levels show that the model will recommend appropriate furniture if it recognizes the colour and theme. This approach not only enhances the creative potential of designers but also empowers clients to actively engage in the design process its seamless integration of virtual and physical elements, emerges as a transformative force in shaping the future of interior design and user engagement.

Keywords: *Augmented reality, Interior designing, Object placement, Colour and theme based augmented reality, Building interior*

DEVELOPING AN AI-POWERED CHATBOT TO ASSIST UNDERGRADUATES IN OVERCOMING EXAM STRESS

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Undergraduate students frequently encounter academic stress, necessitating accessible and effective coping mechanisms. AI-driven interventions like chatbots have emerged as potential solutions to provide mental health support to students. This study focuses on developing an AI chatbot based on cognitive behavioural therapy principles to address the mental health needs of undergraduate students. The primary objective is to create and evaluate an AI chatbot capable of delivering personalized support to undergraduate students experiencing academic stress. The chatbot aims to engage students in conversations, classify cognitive distortions in their thought patterns, and offer tailored coping strategies based on identified distortions. The chatbot utilizes OpenAI's GPT-3.5 turbo LLM for generating human-like conversations and incorporates a vector database for storing domain-specific knowledge. Pre-chat questionnaires assess students' stress levels, while text inputs undergo preprocessing and OpenAI embeddings for intent classification. Machine learning models, including Support Vector Machines (SVM), Multinomial Logistic Regression, and Random Forest, are employed for cognitive distortion classification. Additionally, intent classification using cosine similarity is utilized to enhance conversational understanding. In the evaluation of machine learning models, SVM outperformed, achieving an accuracy of 85.94% in classifying cognitive distortions. Logistic Regression and Random Forest exhibit accuracies of 78.5% and 71.6%, respectively. Challenges related to dataset acquisition and prompt engineering effectiveness are identified. Future work is proposed to improve dataset quality, explore multilabel text classification, and refine cognitive distortion categories. The study underscores the potential of AI chatbots in providing valuable mental health support to undergraduate students.

Keywords: *Cognitive behavioural therapy, Large language models, Machine learning models, Mental health support*

GRAYSCALE IMAGE COLORIZATION USING MACHINE LEARNING

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In today's rapidly evolving digital era, the intersection of machine learning and visual content enhancement presents a groundbreaking field of study. This study dives into the fascinating world of using machine learning to add colour to black-and-white images. It's like taking old or simple pictures and filling them with vibrant colours, making them more appealing and helping us connect with history or see things in a new way. The research begins by looking closely at what others have done before, mixing ideas from colour science, computer methods, and a deep understanding needed to make these grayscale images come alive with colour. The core of this project introduces a fresh approach that combines art and technology precisely. It uses advanced deep learning models, specifically MobileNetV2, ResNet50, and EfficientNetB0. These are fancy names for computer programs that can learn and adapt by themselves. The idea is to reveal the colours hidden in different shades of gray by training these models with a lot of images. The process includes preparing the images for the model, training the model to understand how to add colour, and then checking how well it works. The goal is to make the jump from black-and-white to colour not just scientifically accurate but also pleasing to the eye. The results show that this model can create realistic colours for old photos or give a new look to modern images. This research is important because it shows how machine learning can change the way we see images, adding significant value to the field of image colorization. Further, the study suggests exploring more advanced models and techniques that can handle complex images better. This opens exciting possibilities for using artificial intelligence not just in enhancing historical photos but also in various applications like virtual reality, film restoration, and digital art, highlighting the exciting direction for those interested in the intersection of technology and art.

Keywords: *Machine learning, Image colorization, Grayscale to color, Deep learning, Artificial intelligence*

DRIVER DROWSINESS DETECTION USING IMAGE PROCESSING AND ENSEMBLE LEARNING

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Driver drowsiness is a critical issue that contributes to road accidents worldwide. This research study introduces an innovative approach to detect driver drowsiness, exclusively utilizing different image processing and ensemble learning techniques with the intention of enhancing the accuracy and robustness. The study uses the most efficient camera-input based non-intrusive techniques for improved drowsiness detection, since more accurate systems are often intrusive. Datasets that were collected from publicly accessible sources were preprocessed with the use of different algorithms to extract new datasets for training, which also led to the identification of limitations in certain datasets. Transfer learning models were constructed using the MRL eye dataset by employing popular pretrained machine learning model architectures, which include InceptionV3, MobileNetV2, ResNet50, Xception, and VGG16. The best-performing models, InceptionV3, MobileNetV2, and Xception had remarkable validation accuracies of 95.87%, 91.09%, and 95.17% respectively. These models were integrated into an ensemble learning model with the use of a majority voting technique, demonstrating improved accuracy and performance in drowsiness detection. An alarm was set to be triggered when the cumulative score surpasses a threshold to minimize the risk of accidents. A yawn detection model was also trained using CNN to augment the ensemble model. Despite modest standalone accuracy, the yawn detection model contributed to the overall system to enhance its capability of detecting drowsiness. The study also highlights the need for more comprehensive yawn datasets that are tailored to the specific requirements of driver drowsiness detection, while discussing the limitations that were identified. Furthermore, it discusses the proposed approach in comparison to the existing approaches to demonstrate the key findings of the study, where it is capable of effectively detecting drowsiness non-intrusively. The use of advanced image processing techniques and sensors would improve the performance of the system in the future. In addition, the change of lanes could also be monitored to provide a severe warning to minimize the risk of accidents. The findings also explain the effectiveness of transfer learning and ensemble learning in driver drowsiness detection, while holding promise for advanced road safety and driver monitoring technologies.

Keywords: *Transfer Learning, Ensemble Learning, Drowsiness, Yawn Detection, CNN*

PREDICTING POPULARITY IN SINHALA YOUTUBE VIDEOS USING MACHINE LEARNING ALGORITHMS

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This research explores the rapidly developing field of machine learning techniques used to predict the popularity of Sinhala YouTube videos, a field that lacks specific analytical frameworks. The increasing number of Sinhala videos on YouTube has made it more and more necessary for marketers, platform stakeholders, and content creators to comprehend the complex mechanics of viewer interaction. This study collected data from YouTube by running YouTube API in the Google developer console and gathered a large dataset of 7805 values. The API extracts information about YouTube videos like their titles, descriptions, views, likes, comments, duration, tags, and tags count. Then, we pre-processed this dataset and used it in 8 different machine-learning models to see which one could best predict which videos would be popular. This approach allowed us to analyse a wide range of video features and understand how they relate to popularity on the platform. The Random Forest Regressor is the most successful model of all, with an astounding 84% accuracy rate after extensive hyperparameter tuning. This outstanding result highlights the algorithm's resilience in identifying small trends in the Sinhala YouTube data, which allows it to produce accurate popularity predictions for videos. The Random Forest Regressor's ensemble learning technique is essential for identifying intricate connections between different video qualities and provides insightful information about the preferences and actions of viewers. Additionally, the analysis clarifies the crucial significance that attributes like video length and comment count have in predicting popularity, illuminating important factors that influence viewer interaction in the Sinhala YouTube ecosystem. This research has implications for marketers and content producers, providing them with useful information to enhance audience reach and optimize content strategy. By bridging the gap between machine learning methodologies and the unique characteristics of Sinhala content, this study contributes to the broader discourse on media analytics and audience engagement in the digital age. As the popularity of Sinhala YouTube videos continues to soar, the findings of this research offer invaluable guidance for stakeholders navigating the increasingly competitive landscape of online content creation and distribution.

Keywords: *Sinhala YouTube, Machine Learning, YouTube API, Popularity prediction, Views, hyperparameter tunning*

AN APPROACH FOR PREDICTION OF BLACK PEPPER (*Piper nigrum L.*) CROP PRODUCTIVITY BASED ON WEATHER PARAMETERS USING MACHINE LEARNING

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Sri Lanka's Black Pepper is a major export commodity, known for its high quality and rich flavour. However, as most Pepper cultivations are rainfed, the crop's growth and yield are highly affected by prevailing climatic conditions. It has led to higher fluctuations in production and export. Therefore, understanding the relationship between weather parameters and pepper productivity factors and predicting yield are vital. As a solution, a machine learning-based model has been proposed for predicting yield and quality of pepper with different weather parameters. The main weather parameters affecting yield and quality are rainfall, number of rainy days, drought spells, maximum and minimum temperature, and atmospheric relative humidity. In this study, 30 years of weather, yield and quality data of Pepper were considered in Matale district, Sri Lanka. Two long short-term memory models were developed to predict the yield and quality separately with features selected based on correlation analysis. The pre-processing steps were applied before training the model. The proposed models predict the pepper yield and quality within a range for the given specific weather data with an average error of 20.61% for yield. For the quality prediction model, the mean absolute error for both train and test sets was around 18 – 20%. Yet the mean squired error values for both sets were similar, indicating consistent performance. However, models' performance can be further enhanced by testing under varying weather conditions and crop management practices.

Keywords: *Yield and quality, Climate change, Machine learning, LSTM*

DETECTION OF SINHALA TEXT BASED CYBER-BULLYING USING ONTOLOGY ENGINEERING AND MACHINE LEARNING TECHNIQUES

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This study delves deeply into the multifaceted domain of cyberbullying detection within Sinhala text, leveraging a sophisticated amalgamation of ontology engineering and machine learning methodologies to fortify the resilience of detection mechanisms in the digital landscape. Rooted in a meticulous data collection and preprocessing framework, which encompasses the meticulous selection of data collections, meticulous eradication of duplicates, and rigorous text vectorization processes, the study lays a robust foundation for subsequent model development endeavours. Through a systematic exploration of five distinct machine learning models against the final Sinhala dataset, the Support Vector Machine (SVM) emerges as the undisputed champion, showcasing unparalleled prowess in discerning subtle nuances indicative of cyberbullying behaviours. Subsequently, the research embarks on a profound investigation into ontology integration, orchestrating a dynamic framework for the capture and continual adaptation of offensive lexicon to the ever-evolving landscape of cyberbullying tactics. This symbiotic fusion significantly bolsters the model's perceptiveness to nuanced linguistic cues and contextually contingent manifestations of cyberbullying behaviours, empowering it to navigate the intricate nuances of Sinhala text with unparalleled finesse and acuity. Rigorous evaluation, underpinned by a comprehensive suite of performance metrics encompassing accuracy, precision, recall, and F1-score, underscores the robustness and efficacy of the developed model in detecting cyberbullying instances and effectuating the adept filtration of deleterious content, particularly at the paragraph level where contextual comprehension plays a pivotal role. Ethical considerations permeate the research landscape, accentuating the paramount importance of privacy preservation, consent adherence, and bias mitigation throughout the research trajectory, ensuring responsible and ethical conduct at every stage of the process. Furthermore, the thesis elucidates a comprehensive roadmap for future exploration, advocating for expansive dataset augmentation initiatives, meticulous refinement endeavours of the model architecture and parameters, incorporation of cutting-edge algorithmic paradigms, and exploration of real-time detection and intervention modalities, with the ultimate aim of propelling the field of cyberbullying detection forward and fostering safer and more inclusive digital environments for all individuals, particularly those engaging with Sinhala content.

Keywords: *Cyberbullying, Sinhala text, Ontology engineering, Machine learning, Support vector machine*

ENHANCING CRYPTOCURRENCY PRICE PREDICTIONS WITH MACHINE LEARNING

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This research offers an extensive investigation into the intricate realm of cryptocurrency price prediction, with a primary focus on Bitcoin. Commencing with a deep dive into the foundational principles of cryptocurrency, including its evolutionary trajectory and the bedrock technology of blockchain, the study sets a comprehensive backdrop for understanding the complexities involved. It meticulously examines a spectrum of methodologies employed for predicting cryptocurrency prices, meticulously classifying them into two broad categories: statistical techniques and machine learning-based approaches. An innovative and distinctive approach is introduced for forecasting Bitcoin prices, marked by its integration of historical Bitcoin price data with sentiment analysis drawn from Twitter. Central to this approach are two sophisticated machine learning models: decision tree regression and support vector regression. These models, harnessing the power of data-driven analysis, aim to provide insights into the dynamic and volatile nature of Bitcoin pricing. The efficacy of these models is rigorously assessed through the lens of established error metrics across diverse datasets, encompassing both training and validation sets. The findings illuminate the efficacy of an ensemble approach, synthesizing predictions from both models to yield robust and precise projections of Bitcoin prices. This nuanced understanding of the predictive mechanisms not only enriches the scholarly discourse on cryptocurrency forecasting but also holds significant implications for stakeholders across various domains, including investors, financial analysts, and policymakers. In essence, this research represents a significant milestone in advancing the frontier of cryptocurrency price prediction, forging new pathways for future exploration, and offering actionable insights for navigating the volatile landscape of digital asset markets.

Keywords: *Cryptocurrency, Machine learning, Price prediction, Bitcoin, Financial forecasting*

A NOVEL MACHINE LEARNING MODEL FOR EMOTION RECOGNITION IN SINHALA LANGUAGE SOCIAL MEDIA POSTS ANALYZING TEXT AND EMOTICONS

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The advancements in technology have changed the way people socialize and communicate, with virtual communication becoming the norm through platforms like Twitter, Facebook, and Instagram. These platforms allow individuals to express their opinions on various social and political issues, often through text and emoticons. Understanding emotions expressed in social media posts is crucial for gaining insights into users' sentiments, opinions, and behaviour. However, emotion recognition in social media posts poses a challenge due to the informal and unstructured nature of the text, as well as the presence of emoticons and other non-verbal cues. In this study, a novel machine learning model for emotion recognition in Sinhala language social media posts, analysing both text and emoticons, is proposed. A dataset of social media posts, which includes both text and emoticons, is collected and pre-processed by tokenizing the text, removing stop words, and converting emoticons to their corresponding word representations. Several machine learning algorithms, including Random Forest, Logistic Regression, Multinomial Naive Bayes, Long Short-Term Memory (LSTM), and Support Vector Machines (SVM) are experimented with, and their performance is evaluated using metrics such as accuracy, precision, recall, and F1-score. The results showed that the Logistic Regression algorithm performed the best, achieving an accuracy of an F1-score of 0.88. The Random Forest, LSTM, and SVM also performed well, achieving accuracies of 0.87 F1-score. The Naive Bayes, however, performed poorly, achieving an accuracy of only 0.84 F1-score. Overall, it is demonstrated that machine learning algorithms can effectively recognize emotions in Sinhala language social media posts, and that the Logistic Regression algorithm is particularly well-suited for this task. However, there is still room for improvement, and future research could explore the use of deep learning algorithms and more sophisticated feature selection techniques to further enhance the performance of emotion recognition models in Sinhala language social media posts.

Keywords: *Emotions, Machine learning, Pre-processing, Social media, Sinhala language*

WASTE COLLECTING FLOATING ROBOT FOR STILL WATER BODIES USING OPTIMAL PATH IN REAL-TIME

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The increasing amount of pollution and trash in water sources poses a serious threat to aquatic systems, wildlife, and eventually, human health. Conventional garbage collection and disposal procedures are frequently ineffective, costly, and time-consuming, necessitating new solutions to this important environmental issue. The integration of robotics and artificial intelligence has presented enormous potential in changing waste management operations in recent years. The utilization of garbage collecting floating robots outfitted with real-time optimal path planning algorithms presents a timely solution for effective and sustainable collection of waste in still bodies of water. This study investigated the use of cutting-edge technology, such as autonomous garbage collection floating robots and advanced path planning algorithms, to maximize waste collection in bodies of still water. To address the challenge of surface waste removal and collection, a sophisticated motor-driven collecting system was incorporated. This system facilitates the efficient retrieval and deposition of waste, streamlining the waste collection process. For creating a real-time optimal path for navigating among captured waste objects on water bodies, we leveraged a combination of OpenCV library and Dijkstra's algorithm. In conclusion, this project intended to contribute to a sustainable waste management solution for still water bodies by merging developments in robotics, AI, and optimal path planning, paving the path for healthier and more sustainable aquatic ecosystems and benefiting both the environment and society at large.

Keywords: *Robot, Floating waste, IoT, Water pollution, Real time data, Computer vision, Image processing, Object detection*

MACHINE LEARNING AND LEXICON-BASED HYBRID SENTIMENT ANALYSIS APPROACH FOR MOVIE REVIEWS

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The sentiment analysis of movie reviews is crucial for understanding audience reactions, covering a spectrum from positive to negative or neutral emotions. Traditional lexicon-based methods and machine learning techniques offer different strengths, with this research aiming to combine both for enhanced accuracy and robustness. Emojis in user-generated content are often overlooked yet integrating them into sentiment analysis could deepen emotional insights. By training models on diverse movie review datasets, this study aims to improve classification accuracy, particularly in identifying positive, negative, and neutral sentiments. Under this research, a comparative analysis was established among different machine learning classifiers called Random Forest, Multinomial Logistic Regression, and Linear Regression, Lexicons called Textblob, Vader, and Wordnet. Each machine learning techniques are combined by each lexicon under two scenarios. One scenario is trying out 2 feature extractions called, TD-IDF and Word2vec. Another scenario is including emojis and excluding emojis in pre-processing. In machine learning techniques approach (including emojis), Random Forest with TD-IDF performs well with the Mean Squared Error (MSE) score 0.1833. In lexicon-based approach (including emojis), Wordnet performed well the accuracy score 0.598. In the hybrid approach (including emojis), Random Forest and Textblob with TD-IDF performed well the MSE score 0.00021. In machine learning techniques approach (excluding emojis), Random Forest with TD-IDF performs well with MSE score 0.18. In lexicon-based approach (excluding emojis), Wordnet performed well with accuracy score of 0.605. In the hybrid approach (excluding emojis), Logistic Regression and Textblob with TD-IDF performed well with the MSE score 0.00017. The hybrid approach outperforms the lexicon approach and machine learning approach. Therefore, the hybrid model which was trained using Logistic Regression and Textblob with TD-IDF was used to deploy the final prediction model, since it's the most accurate approach for sentiment analysis. The findings of this study hold suggestions for filmmakers, movie studios, and industry professionals, providing valuable insights into audience perceptions and preferences, thus aiding in decision-making processes, and enhancing the overall cinematic experience.

Keywords: *Sentiment, Movie reviews, Lexicons, Machine learning, Hybrid*

HEALTH PROMOTION

CHANGING FOOD HABITS OF ADOLESCENTS BY ADDRESSING DETERMINANTS OF FOOD HABITS USING HEALTH PROMOTION APPROACH IN SELECTED SCHOOLS IN GALENBINDUNUWEWA

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Food habits among adolescents are important to ensure a healthy adolescent period. The World Health Organization defines adolescents as persons aged 10 to 19. Unhealthy food habits among adolescents cause several health problems. Due to unhealthy food habits, adolescents fail to meet their nutrient requirements. Interventions focused only on knowledge improvement on food habits among adolescents have shown limited success. This study aimed to assess the effectiveness of an intervention designed using health promotion principles with school-going adolescents aged between 11-15 years in changing food habits by addressing the factors affecting food habits. A quasi-experimental study was conducted using two schools as intervention and control groups. The study was conducted in purposively selected schools in the Galenbidunuwewa education zone. Current food habits, factors associated with food habits, food consumption patterns among adolescents and knowledge related to food habits were assessed using a self-administered questionnaire. Determinants those could contribute to food habits were identified and prioritized and the activities were designed and implemented with adolescents in the intervention group through facilitated group discussions. Progress was monitored using indicators developed with the adolescents. Post-intervention evaluation was conducted using the same questionnaire with both groups and focus group discussions were conducted only with the intervention group to explore the changes that happened as a result of the intervention. There were 62 adolescents in the intervention group and 60 adolescents in the control group. Around half of the adolescents in both groups skipped breakfast in the pre-intervention phase; 46.8% in the intervention group and 52.4% in the control group. There was a significant reduction in skipping breakfast in the intervention group, from 30 (48.3%) to 11 (17.7%) adolescents ($p < 0.001$ chi-square). Eight determinants were identified by the adolescents. Healthy food consumption among the adolescents in the intervention group significantly improved compared to the control group ($p < 0.001$ chi-square). Fast food and confectionary consumption among adolescents in the intervention group was significantly reduced compared to the control group ($p<0.001$ chi-square). This study concludes that improving knowledge and practices related to food habits using the health promotion approach improves the food habits of adolescents.

Keywords: *Food habits, Adolescents, Practices, Consumption, Knowledge*

CHANGING THE KNOWLEDGE, ATTITUDES, AND PRACTICES REGARDING SMOKELESS TOBACCO (SLT) USE AMONG ADULT FACTORY WORKERS IN ANURADHAPURA USING THE HEALTH PROMOTION APPROACH

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Smokeless tobacco (SLT) is a chemical compound usually consumed through the mouth or nose in the form of chewing, spitting, dipping, or snuffing without burning. Industrial workers using tobacco-based products can increase absenteeism and lower productivity. The workplace is one suitable context to execute interventions to make tobacco-free environments. The study aimed to assess the effectiveness of a health promotion intervention in changing the knowledge, attitudes, and practices of using SLT among factory workers in Anuradhapura. The sample consisted of 70 factory workers, mean age 31.09 years (SD=10.39), 70% male, 30% female and 67.1% were married. A pre-test, post-test interventional study design was used and conducted in three main phases. In the pre-intervention phase, researcher engaged with the factory workers and collected data using a self-administered questionnaire. During the intervention phase, a health promotion intervention was mutually designed and delivered for a period of four months. Determinants were identified and prioritized by factory workers through continuous discussions and activities were implemented. The progress of the process was monitored using participatory methods. Post-interventional data collection was conducted using the same self-administered questionnaire and focus group discussions. The socio-demographic data and data on the level of knowledge, attitudes and practices were analysed using mean, standard deviation, and percentages. Inferential statistics such as Wilcoxon signed rank test, Pearson correlation coefficient and Chi-square test were used to assess the effectiveness of the intervention. Qualitative data were analysed thematically. Study results showed no significant difference in the socio-demographic data and the existing knowledge, attitude, and practices of SLT use ($p>0.05$). Significant differences were observed for several variables in their existing knowledge, attitudes, and practices in the pre-assessment. Factory workers were enabled to identify 10 underlying determinants that affect the SLT use and four activities were developed to address it. There was a significant improvement in the knowledge regarding SLT use ($p=0.000$, Wilcoxon signed-rank test). Positive correlations were observed with the changes in knowledge and attitude ($r=1.000$, Pearson Correlation coefficient) and pre-post practices on SLT use ($r=0.559$, Pearson Correlation coefficient). The delivered health promotion intervention was effective in changing the knowledge, attitudes, and practices regarding SLT use among adult factory workers in Anuradhapura.

Keywords: *Smokeless tobacco use, Factory workers, Health promotion*

Acknowledgements: Authors would like to acknowledge the factory workers, supervisors, and the managers of the private tile factory in Anuradhapura.

EFFECTIVENESS OF A HEALTH PROMOTION INTERVENTION TO REDUCE PHYSICAL BULLYING AMONG ADOLESCENTS IN TERMS OF CHANGES IN THE KNOWLEDGE, PRACTICES AND ATTITUDES OF ADOLESCENTS TOWARDS BULLYING IN A/AL- NOOR MAHA VIDYALAYA, IKKIRIGOLLEWA, ANURADHAPURA DISTRICT

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Physical bullying is using someone's bodily actions to exert power over peers. Unlike other forms of bullying, the effects of physical bullying can be easier to identify. The local evidence pertaining to peer bullying among school-going adolescents are scarce. Hence, the objective of this study was to assess the effectiveness of a health promotion intervention to reduce the physical bullying among adolescents in terms of changes in knowledge, practices and attitudes of adolescents towards bullying in A/Al – Noor Maha Vidyalaya, Ikkirigollewa in Anuradhapura District. A pre-test and post-test study was conducted in three phases; pre-intervention, intervention and post intervention. In the sample of 50 adolescents the mean age was 13.5 years where majority were females (n=32, 65. 3%). Existing level of knowledge, practices and attitudes were assessed using the self-administered questionnaire (SAQ) and focus group discussions (FGD). The health promotion intervention was designed and implemented with the adolescents for four months. The steps of the intervention included; engagement with the adolescents, identifying reducing the physical bullying as a goal, identifying and analysing determinants, identifying actions to address the selected determinants and implementing the actions while monitoring the progress. In the post intervention phase changes were assessed using the same SAQ, FGD with adolescents and key informant interview with parents and teachers. Quantitative data were analysed using descriptive statistics and inferential statistics while qualitative data were analysed thematically. Paired t- test, Marginal homogeneity test and Wilcoxon signed ranked test were performed to determine the effectiveness of the intervention. Results showed, significant improvements in the knowledge [Pre Mean=2.34 (SD=0.26); Post Mean=2.75 (SD=0.35); $p<0.001$], attitudes [Pre Mean=2.90 (SD=0.30); Post Mean=3.1 (SD=0.32); $p<0.001$], practices [Pre Mean=1.56 (SD=0.19); Post Mean=1.69 (SD=0.28); $p<0.001$]. There is a significant reduction in the experience of physical bullying ($t=-14.672$, $p<0.001$, $df=49$) where 49% were not bullied and 42.9% were not involved in bulling. Responding for the bullying has increased among adolescents ($p<0.001$). The intervention based on health promotion principles is effective in reducing the physical bullying among adolescents in terms of changes in the knowledge, practices and attitudes.

Keywords*: Adolescents, Physical bullying, Determinants, Health promotion, Knowledge, Practices, Attitudes*

Acknowledgments: Authors would like to acknowledge the adolescents, school administration and staff.

EFFECTIVENESS OF A HEALTH PROMOTION INTERVENTION TO REDUCE THE RISKS OF UNINTENTIONAL HOME INJURIES BY IMPROVING HOME ENVIRONMENT IN RURAL VILLAGES OF ANURADHAPURA DISTRICT

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Injury is one of the world's most preventable and critical public health issue. Higher mortality and morbidity are reported as a result of unintentional injuries among children around the world, and the situation in Sri Lankan villages has no exemption. This study aimed to assess the effectiveness of a health promotion intervention in reducing the risks of unintentional home injuries in children by improving mothers' related knowledge, attitudes, and practices. A quasi-experimental study was conducted with 62 mothers in the intervention group (IG) and 63 mothers in the control group (CG). The level of injury prevalence, knowledge, and attitudes of mothers on child injury were assessed using an interviewer-administered questionnaire, and practices were assessed using an observational checklist. Only in the post-evaluation focus group discussions were conducted with mothers of IG. The IG was facilitated to identify determinants of unintentional home injuries in children, and activities were designed, developed, and implemented with the mothers to address those. Progress was monitored using indicators, and post-evaluation of both groups was done with the same study instruments. There were no differences in terms of socio-demographic characteristics between groups ($p<0.05$). The mean (SD) ages of mothers in IG were 34.76 (7.73) and 33.65 (6.07) in CG. There was a reduction in injuries due to falls from 80.6% to 6.5%. Other injury types were also significantly reduced in the IG. Cuts, burns, drownings, suffocations, poisonings, animal-related injuries, and electrical shock cases were significantly reduced in IG compared to CG. There were statistically significant improvements in mothers' practices compared to their pre-level ($p<0.05$). In comparison with the CG, the IG demonstrated changes in practices related to the risks of drownings, falls, burns, cuts, poisonings, electrical shocks, and suffocation ($p<0.05$). Mothers of the IG claimed that they had increased their knowledge of the importance of concerning risks in the home environment, changed their attitudes toward implementing childproofing measures, and practiced promoting safe storage of hazardous substances in the post-evaluation done through focus group discussion. In conclusion, an appropriately planned delivery of health promotion intervention was effective in achieving the expected outcomes of the study.

Keywords: *Health promotion intervention, Home injuries*, *Children, Child safety*

EFFECTIVENESS OF A HEALTH PROMOTION INTERVENTION DESIGNED TO IMPROVE SELECTED ASPECTS OF PSYCHOLOGICAL WELLBEING OF SCHOOL-GOING ADOLESCENTS IN ANURADHAPURA DISTRICT

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Adolescence is a critical transition period between childhood and adulthood. Nearly 50% of mental disorders have an onset during adolescence, with many impacting individuals by the age of 14. General objective of this study was to assess the effectiveness of a health promotion intervention designed to improve selected aspects of psychological wellbeing such as decision-making skill, healthy relationships, happiness, and positive attitude for education among schooling adolescents in Anuradhapura district. A quasi-experimental study design was used to assess the effectiveness of the intervention. Two adolescent groups in grade nine, in two selected schools in Anuradhapura district were chosen as the intervention group (IG) and control group (CG). The study used convenience sampling for both the study setting and the study population, with fifty in each group. The Health Promotion intervention was implemented only with the IG. The steps of the intervention included; identification of a goal in terms of psychological wellbeing, identifying and analysing its determinants, identifying actions to address selected determinants and implementing those actions while monitoring progress. All steps carried out mutually with students in the IG. Data was collected through a self-administered questionnaire, focus group discussions and key informant interviews. Quantitative data were analysed using descriptive statistics and inferential statistics, while qualitative data were analysed using framework analysis with deductive approaches. No significant differences were observed in the baseline socio-demographic factors between the IG and CG. When comparing the change in mean scores a significant improvement is seen in decision-making skills (IG=4.0600, CG=0.0600, $p<0.001$), healthy relationships (IG=2.0800, CG=0.3800, $p<0.001$), happiness (IG=1.1800, CG=0.0400, $p<0.001$), positive attitudes toward the education (IG=4.5200, CG=0.1000, $p<0.001$) and total psychological wellbeing (IG=11.8400, CG=0.5800, $p<0.001$). This study concludes the health promotion intervention is effective in improving above aspects of psychological wellbeing among schooling adolescents.

Keywords: *School, Adolescents, Psychological, Wellbeing, Health promotion*

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MATHEMATICS

A SPATIO-TEMPORAL ANALYSIS OF DENGUE EPIDEMICS IN SRI LANKA AT THE PROVINCIAL LEVEL

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Infectious disease modelling holds a crucial role in comprehending the dynamics of disease spread, offering valuable insights for prevention and control strategies. The widely recognized Space-time ARIMA model is among the most frequently employed spatio-temporal statistical models for studying such issues. In this study, a spatio-temporal modelling framework was implemented that integrates Space-time ARIMA models at the provincial level of Sri Lanka to characterize the dynamics of dengue epidemics. To assess the spatial distribution patterns, the Moran's I index was utilized that investigates whether statistical clustering or dispersion was exhibited in the spatial distribution of dengue incidence in each province. Additionally, Pearson's correlation analysis was employed to examine the relationship between dengue incidence and Provincial Gross Domestic Product data. This economic indicator serves as a fundamental measure to assess the level of economic development within each province. Space-time ARIMA models were formulated for each province and the best-performing provincial models were selected to forecast the dengue incidence for the years 2023 and 2024. The results indicated that, based on the calculated Moran's I statistics, the spatial distribution of dengue incidence rates in Sri Lanka demonstrates a clustering pattern. Furthermore, this clustering tendency is observed to intensify over the years progressively. The findings further revealed a robust correlation between dengue incidences and the economic development level of the provinces. Utilizing the best ARIMA models selected at the provincial level resulted in enhanced forecasting performance for the years 2023 and 2024. This study reveals that regional disparities in dengue control in Sri Lanka from 2007 to 2022 underscore the importance of collaborative efforts among provinces. Effective reduction of dengue incidence requires tailored response mechanisms in representative areas.

Keywords: *Dengue incidence, Space-time ARIMA, Moran's I index, Trend prediction, Provincial Gross Domestic Product data*

THE INCIDENCE COLOURING FOR HONEYCOMB GRAPHS & INCIDENCE COLOURING APPLICATION

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The notion of the incidence chromatic number of a graph was first proposed by Brualdi and Massey (1993). For an undirected graph $G = (V, E)$ with the set of vertices $V(G)$ and the set of edges $E(G)$, its incidence chromatic number, denoted by $\chi'(G)$ or $\mathrm{inc}(G)$, is the minimum number of colours needed for incidence colouring, which is an assignment of colours to the edges such that no two incident edges have the same colour. A Honeycomb graph $(H_{n,m})$, where n denotes the number of rows of the graph and m denotes the number of cells in each row, which is a type of graph that has a hexagonal or Honeycomb-like structure. A complete graph (K_n), a specific graph, is an undirected graph where every pair of distinct vertices is connected by a unique edge. Traffic management systems play a crucial role in managing and controlling the flow of traffic on transportation systems, communication network systems, pipe networks, circuits of a network electricity, etc. The optimization of traffic systems using graph colouring is a concept derived from graph theory. Each path connected to the junction is represented by two nodes. The first node is for the leaving lane of the path and the other one is for the entering lane of the path and the paths between intersections nodes are represented by edges. The traffic network can be effectively controlled by applying the concept of incidence colouring. In this study, we consider a Honeycomb graph which is made up of hexagonal cells. Then, it is proved that the Honeycomb graph can be 4-incidence colourable which means that the incidence chromatic number, $\chi'(H_{n,m}) = 4$ for any number of rows (n) and any number of cells in the row (m) using the general formulas. An algorithm is also developed to minimize the number of traffic phases at the network junction with any number of paths connected to the junction and optimize the traffic in the network system.

Keywords: *Incidence Chromatic Number, Incidence Colouring, Honeycomb Graph, Complete Graphs*

BEES ALGORITHM FOR SOLVING TRANSPORTATION PROBLEM

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Efficiently solving large-scale Transportation Problems (TPs) is a critical aspect of operations research, often framed as a Linear Programming Problem (LPP). This study introduces an innovative approach by integrating the steps of the Bees Algorithm (BA) into the traditional methods of addressing TPs. The BA is employed to modify the initial transportation table, optimizing the distribution plan for a single commodity from multiple sources to various destinations. Unlike conventional techniques, the duration of modifying the transportation table is determined by the fitness factor condition, ensuring computational efficiency and a balance between exploration and exploitation. This research presents a dynamic solution strategy, where the transportation table is adapted until the fitness factor condition is met. The BA facilitates a streamlined and automated process, significantly reducing the manual effort required for calculations. The study focuses on minimizing both time and manual intervention while maintaining solution quality. The unit transportation cost is assumed to be constant, simplifying the computational complexity. Upon satisfying the fitness factor condition, the study seamlessly transitions to the basic method for solving transportation problems, ensuring the optimality of the obtained solutions. Numerical illustrations demonstrate the effectiveness of the proposed approach, and the results are rigorously tested for optimality. A notable feature of this methodology is its adaptability to various transportation scenarios, making it applicable to a wide range of logistics and supply chain-related issues. The simplicity of the approach, coupled with its automated nature, makes it particularly valuable for decision-makers seeking efficient and user-friendly solutions. In summary, this research contributes to the field by combining the principles of the BA with traditional transportation problem-solving methods. The resulting approach offers a balance between computational efficiency and solution quality, making it a viable and accessible tool for decision-makers in logistics and supply chain management

Keywords: *Bees Algorithm, Linear Programming Problem, Optimal Solution, Transportation Problem*

RAINBOW CONNECTION NUMBER OF SPECIAL TYPE OF GRAPHS

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Let $G = (V(G), E(G))$ be a nontrivial, finite, and connected graph. An edge-colouring of G is defined as a function $c: E(G) \rightarrow \{1,2, \dots, k\}$ for some $k \in N$, such that adjacent edges can be coloured by the same colour. Consider any two vertices u and v in G. A path P from u to v in G , denoted by $u - v$ path, is called a rainbow $u - v$ path, if there are no two edges along the $u - v$ path having the same colour. The distance between two vertices u and v is denoted by $d(u, v)$. A graph G is called rainbow-connected under c if for every two vertices u and v of G, there exists a rainbow $u - v$ path. An edge-colouring in which G is rainbow connected is called a rainbow colouring. In this case, the colouring c is called a rainbow k-colouring of G. The minimum positive integer k for which there exists such a k-colouring is defined as the rainbow connection number of G, denoted by $rc(G)$. This study introduces two new graph classes, namely Generalized Helm Graph (GHG), ($GH_{2,n}$) and Generalized Star Graph (GSG), $GS_{2,n}$. Then, it is proved that there is a rainbow path between every two distinct vertices in these graphs and that both graphs are rainbow-connected. The rainbow connection number of the GHG, $rc(GH_{2,n})$ is equal to the number of pendant vertices of the graph. The rainbow connection number of the GSG, $rc(GS_{2,n})$ is equal to the number of radial vertices of the star graph. This study is open for the $rc(GH_{r,n})$, where "r" is the number of cycles in the Helm graph and the $rc(GS_{r,n})$, where "r" is the number of petals connected in each edge of the star graph.

Keywords: *Edge Colouring, Rainbow Colouring, Rainbow-Connected, Generalized Helm Graph, Generalized Star Graph*

ENHANCE THE PREDICTION PERFORMANCE OF STOCK MARKET USING CLUSTERING TECHNIQUES

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The dynamic and unpredictable nature of financial markets has led to an increased focus on forecasting economic and financial time series, particularly in the stock market, driven by successful Artificial Intelligence (AI) technologies. This study aims to improve stock market prediction in Sri Lanka by leveraging advanced clustering techniques. Unlike traditional linear and non-linear time series algorithms, deep learning algorithms like Recurrent Neural Network (RNN), Long Short-Term Memory (LSTM), and Gated Recurrent Unit (GRU) are gaining prominence for their ability to autonomously learn hierarchical representations and adapt to market changes. Here a framework is proposed that prioritizes clustering as a crucial pre-processing step to enhance the quality of deep learning training models. To optimize clustering, the Logistic Weighted Dynamic Time Warping (LWDTW) similarity measure is employed, which modifies the cost weight function of Weighted Dynamic Time Warping (WDTW) by integrating a logistic probability density distribution function. This extension is designed to capture the relative importance of return observations when calculating distance matrices. Then a clustering-enhanced deep learning framework is proposed to optimize and improve the accuracy of stock price prediction. The proposed framework combines three matured deep learning forecasting models, namely RNN, LSTM, and GRU. In addition, a comprehensive comparison is done between the above three deep learning forecasting models utilizing only the daily closing Colombo Stock Exchange (CSE) stock price data and the proposed clustering-enhanced RNN, LSTM, and GRU models. The comparison aims to assess the relative performance and effectiveness of these approaches in predicting stock prices. In this work, it is empirically observed that the combination of the LWDTW method with the LSTM architecture yields superior efficiency and exceptional forecasting performance, with the highest R^2 value of 0.9788 in comparison with the alternative approaches. The findings illuminate the benefits of incorporating clustering techniques into deep learning models for stock price prediction, offering insights into their respective strengths and limitations within the Sri Lankan context. The integration of clustering techniques and deep learning models offers a promising approach for achieving more precise and reliable stock price forecasting, thereby facilitating informed decision-making within the Sri Lankan financial market.

Keywords: *Clustering techniques, Deep learning algorithms, Financial time series data, Stock price prediction*

A NOVEL HEURISTIC APPROACH TO THE ONE-DIMENSIONAL BIN PACKING PROBLEM

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Placing a set of items of different sizes into identical bins in a way that minimizes the number of containers used as much as possible is known as the bin-packing problem (BPP), which is a combinatorial optimization problem. In bin packing problems, the dimensions are the number of features or attributes that are utilized to characterize the items and bins. Depending on the dimensions, bin packing problems can be categorized as one-dimensional, two-dimensional, or three-dimensional. Among these, the One-Dimensional Bin-Packing Problem (ODBPP) is one of the best-known optimization problems, and it has a significant number of applications. Finding the fewest possible bins is the problem, as it must be followed in order to load all the products while considering the bin capacity. The literature witnesses that different techniques have been developed in the past to solve the bin-packing problem. In some techniques, the focus is on finding an initial basic feasible solution, while the rest focuses on finding the optimal solution to the Bin-Packing Problem. This paper presents a new algorithm for the ODBPP and provides comparative examples with heuristic algorithms such as Next-Fit (NF), First-Fit (FF), Best-Fit (BF), Worst-Fit (WF), First Fit Decreasing (FFD), and Best Fit Decreasing (BFD). Further, a C-programming code was developed along with this proposed algorithm to solve the ODBPP. Compared to the proposed method, the code is asserted for its exceptional optimization, accuracy, efficiency, and maintainability. This code helps reduce the amount of time and resources required and delivers faster and more effective results. This study presents a new algorithm for the ODBPP, which is based on the progressive reduction of the number of bins used by a previously constructed solution and has proven to provide near-optimal solutions to a reasonable degree of satisfaction. The algorithmic approach proposed by this study is less complicated compared to the well-known meta-heuristic algorithms in the literature. Furthermore, the proposed method is illustrated using a case study.

Keywords: *Bin-packing problem (BPP), Heuristic algorithms, New algorithm, One-dimensional, Optimal solution*

COMPARATIVE STUDY OF TWO-PHASE HEURISTIC ALGORITHMS TO SOLVE THE MULTI-DEPOT TRAVELLING SALESMAN PROBLEM

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The Traveling Salesman Problem (TSP) is a classical combinatorial optimization problem that has multiple forms or variations, each with unique properties and limitations. The Multi-Depot Traveling Salesman Problem (MDTSP) is a special variant of the TSP. There are plenty of real-world applications of the MDTSP, and it is a challenging optimization problem in transportation and logistics. Evaluating the effectiveness and efficiency of various heuristic combinations in solving the MDTSP is the main goal of this study. The Two-Phase Heuristic Approach consists of an initial clustering phase where the clusters of customers are formed using the Density-Based Spatial Clustering of Applications with Noise (DBSCAN), K-medoids, or Hierarchical Clustering (HC). This is followed by a TSP-solving phase that uses either Ant Colony Optimization (ACO) or Genetic Algorithms (GA). Six alternative configurations by combining a clustering algorithm and a TSP-solving algorithm are methodically assessed in this research: DBSCAN with GA, DBSCAN with ACO, K-medoids with GA, K-medoids with ACO, HC with GA, and HC with ACO. Crucial performance parameters like convergence properties, computational efficiency, and solution quality are used to evaluate each setup. The results of the comprehensive testing using a set of benchmarked problem instances, provide valuable insights into the strengths and weaknesses of each heuristic combination, contributing to a better understanding of their suitability for solving MDTSP. Based on the statistical analysis of the solutions obtained across all six combinations of algorithms, it is recommended to employ the combination of K-medoids with GA for addressing both small-scale and large-scale MDTSPs. Additionally, the combination of DBSCAN with ACO is specifically recommended for solving the medium-scale MDTSPs. These recommendations are drawn from the observed performance and statistical analyses, highlighting the applicability of each combination to different problem scales. This work provides a foundation for future investigation and improvement of heuristic approaches for solving MDTSP.

Keywords: *Multi- Depot Travelling Salesman Problem, Heuristic Clustering Methods, Genetic Algorithms, Ant Colony Optimization*

A NEW THIRD-ORDER APPROXIMATION FOR THE FRACTIONAL DERIVATIVES

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Fractional derivatives belong to the branch of mathematics that studies derivatives of non-integer orders. In nature, fractional derivatives are non-local operators which means that a fractional derivative of a function at a particular point in a considered domain of the function depends on functional values of both the domain points that precede that point and itself. The non-local characteristic of fractional derivatives plays a significant role in the study of the memory and hereditary properties of a range of physical materials and processes. However, because of the non-locality, evaluating fractional derivatives and solving fractional order differential equations has become very cumbersome. Almost all analytical or exact formulas for fractional order derivatives are not in closed form. Although the existing analytical methods for integer order differential equations can be applied to fractional order differential equations, their solution forms are very complicated to use. Consequently, numerical computation of fractional derivatives has received continuous attention in the literature. However, the existing numerical methods also have some drawbacks, including lower accuracy, instability, inefficiency, etc. The Grünwald approximation is the first finite difference approximation for fractional derivatives which has the first-order accuracy. The explicit and implicit approximate schemes of the Grünwald approximation are also not stable. As a remedy to the stability of the Grünwald approximation, the shifted Grünwald approximation was proposed, whereas it is also yet of the first-order accurate. Therefore, higher-order numerical approximations for computing fractional derivatives are of great importance. In this study, a new third-order accurate finite difference approximation is constructed for fractional derivatives. It is obtained from a recently developed approximation of order 2 through a weighted average of two different shifts. A pair of distinct shifts yields a unique third-order approximation, thereby it may also be considered as a family of third-order approximations. The third-order approximation is also applied to a one-dimensional steady-state problem and numerical test examples of the steady problem are given to demonstrate its fruitfulness.

Keywords: *Fractional Derivatives, Generating functions, Grünwald approximation, Order 2 approximation, Steady State Problem*

TOURIST ARRIVAL FORECASTING IN SRI LANKA AMIDST COVID-19 USING DEEP LEARNING AND MACHINE LEARNING APPROACH

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Tourism, a significant contributor to Sri Lanka's GDP and employment, is susceptible to various crises, making accurate forecasting of tourist arrivals crucial. This study introduces a novel approach to this issue by employing deep learning and machine learning models, methods yet to be explored in previous research on Sri Lankan tourist arrival data. Our research fills the gap in the literature by considering the impact of the COVID-19 pandemic, a period that has not been previously studied, and has brought unpredictability and volatility to tourist arrivals. We utilized historical tourist arrival data spanning from 1972 to May 2023 and applied MinMaxScaler() for data normalization. Our exploration included LSTM, BiLSTM, ANN, SVR, and RF models. The ANN model outperformed others, demonstrating superior forecasting results for both pre-and post-COVID-19 scenarios. Despite limitations in pre-COVID-19 forecasting, our models adapted to these changes and showed promising results. We believe that comprehensive feature engineering, hyperparameter tuning, and the inclusion of additional data sources can further enhance their performance. In conclusion, this research underscores the potential of deep learning and machine learning models for forecasting tourist arrivals in Sri Lanka amidst the COVID-19 pandemic. The ANN model, in particular, offers valuable insights into the tourism industry's planning and decision-making processes. This research is a significant contribution to the existing body of knowledge as it provides a comprehensive analysis of the impact of the COVID-19 pandemic on tourist arrivals in Sri Lanka. It also presents a detailed comparison of various deep learning and machine learning models, highlighting their strengths and weaknesses in forecasting tourist arrivals. Furthermore, it proposes potential improvements to enhance the accuracy of these models, paving the way for future research in this area.

Keywords: *COVID-19 impact, Deep Learning, Machine Learning, Pandemic*

FORECASTING MISSING DATA IN ADULT-CENSUS BIG DATA USING MACHINE LEARNING ALGORITHMS

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The prevalence of missing values in big data poses a critical challenge to data analysis while compromising the accuracy of insights. This study evaluates Machine Learning (ML) techniques for managing missing data in extensive datasets, highlighting the significance of resilient methodologies in big data analysis. The exploration is anchored in the 'Adult-Census Income' dataset from the UCI Machine Learning Repository, which incorporates a wide array of demographics and attributes from the 1994 U.S. Census, spanning numerical, categorical, and binary variables. To ensure the robustness of this study, 100 simulations were conducted, where the performance of K-Nearest Neighbors (KNN) Imputation, Support Vector Machine (SVM), and Bayesian Networks (BNs) ML techniques under the three scenarios of missing values: Missing Completely At Random (MCAR), Missing At Random (MAR), and Missing Not At Random (MNAR). These scenarios were produced using completely random deletion, random deletion, and not random deletion respectively. The approach included a thorough investigation and the use of robust metrics, like average Mean Absolute Error (MAE) and average Root Mean Squared Error (RMSE). Once SVM was identified as the most effective ML technique for managing missing data in the particular dataset, the dataset was normalized for predicting the income column. The features of the dataset were dropped individually and 100 simulations were performed each time for analysing the impact of each feature on income. During this analysis, it was observed that the 'education.num' factor significantly influenced accuracy. An SVM classifier was used in income prediction with the use of the complete dataset and in the absence of 'education.num', which yielded average accuracies of 83.09% and 80.92% respectively. A separate predictive regressor model was built using SVM to forecast values for 'education.num'. With the previously forecasted values, the average accuracy was calculated as 82.62%, demonstrating the effectiveness of the predictive model when the missing values in other columns were disregarded. The study demonstrates the difficulties of dealing with missing values in big data, while the adoption of different ML techniques is capable of making predictions more accurate by filling in the missing values for crucial decision-making processes.

Keywords: *Missing Values, Support Vector Machine, Income Prediction, Adult Census*

PHYSICS

WATER SPLITTING BY CARBON (C), NITROGEN (N) AND CHROMIUM (Cr) DOPED TITANIUM DIOXIDE (TIO_2)

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Water splitting, the process of decomposing water into its constituent elements, hydrogen (H_2) and oxygen (O_2), is characterized by a notably positive change in the Gibbs free energy of 237 kJ/mol, signifying its thermodynamic uphill nature. Typically, when incident light carries energy greater than the band gap of the semiconductor catalyst, it triggers the generation of electron-hole pairs in the conduction and valence bands, respectively. These photo-generated electron-hole pairs then initiate redox reactions akin to electrolysis, whereby electrons reduce water molecules to produce H_2, while holes oxidize water molecules to yield O_2. Titanium dioxide (TiO_2) stands as a widely employed photo-catalyst for water splitting, predominantly under ultraviolet (UV) irradiation conditions.

Several factors can affect water splitting such as catalyst material, bandgap energy, and light source. In the present work, water splitting by doping titanium dioxide with Carbon, Nitrogen and Chromium was investigated. Changing the chromium concentration by using K_2CrO_4 while keeping the Carbon and Nitrogen concentration constant, the band gap was calculated. Results showed that theTiO_2 doped with Carbon, Nitrogen, and Chromium can reduce the bandgap and increase light absorption thereby increasing the water-splitting reaction. The optimum bandgap of1.975 eV was obtained from 0.3 g of K_2CrO_4 which matches the given UV spectra. EDX calculations confirmed a high percentage of Cr compared to Nitrogen and Carbon. Cr solely act as a catalyst is confirmed by observing only OH, CO_2 and C-C vibrational stretching peaks using FTIR. SEM images show that the prepared particles are almost spherical in shape with a diameter varying from 1 to 5 μm accounting for a large surface area.

Keywords: *Water Splitting, Doping, Bandgap, Chromium, Titanium Dioxide*

AN ALGORITHM FOR TWO-DIMENSIONAL MODELLING OF THE SEDIMENT DISTRIBUTION IN SEDIMENTARY BASINS INTERPRETING SATELLITE GRAVITY ANOMALIES

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The sedimentary basins are characterized by complex sediment distributions, which are a crucial factor for various applications such as hydrocarbon exploration and environmental studies. Traditional models, which assume constant sediment density, falter in the face of this complexity. Existing models for sediment distribution in sedimentary basin often consider sediment density as a constant. Previous studies have found that sediment density of sedimentary basins with a thick sediment layer varies quadratically with the height of the sediment layer. Currently, the absence of dedicated software capable of accurate modeling of sediment distribution considering quadratic variation of the sediment density in sedimentary basins poses a significant limitation in the field. To overcome this research gap, this study introduces an algorithm for two dimensional modeling of the sediment distribution in sedimentary basins interpreting satellite gravity anomalies. The algorithm considers the quadratic variation of sediment density with sediment height. It interprets satellite gravity anomalies to delineate sediment distribution in a 2D framework. The algorithm is developed using Python programming language (Numpy, Pandas and Matplotlib) in Google Colab environment. The developed algorithm is validated against existing models designed for constant sediment density, comparing gravity responses attributed to subsurface layers excluding the sediment layer. Subsequently the validated algorithm was applied to the Mannar basin of Sri Lanka. The study is unique since introducing this algorithm not only advances the modelling of sediment distribution with high accuracy but also extends its applicability to model various oceanic structures with high sediment thickness characterized by density contrasts with the background. The future work includes converting the algorithm into a software package for the scientists to accurately model the sediment distribution considering quadratic variation of the sediment density in sedimentary basins.

Keywords: *Gravity Method, Python Programming, Quadratic Density Variation, Sedimentary Basin, Sediment Distribution Modelling*

QUANTITATIVE CHARACTERIZATION OF SUB SURFACE WATER QUALITY BY USING ADVANCED ELECTRICAL RESISTIVITY IMAGING AND INVERSE MODELING TECHNIQUES

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In the realm of groundwater quality assessment, the conventional practice of tube well drilling is both time-consuming and expensive. In response to this challenge, a groundbreaking methodology has been introduced, utilizing electrical resistivity data to predict water quality without the need for intrusive drilling. The aim of the present work was to establish correlations through an in-depth analysis of resistivity and geochemical data that could accurately unveil the important water quality parameters. In order to facilitate this investigation, specialized software, referred to as "resist software" was employed for the digitization of resistivity and geochemical data. Subsequently, scatter plots were generated for natural, normalized, and logarithmic values. The correlation analysis revealed that natural values show limited correlations whereas logarithmic values show substantial correlation between electrical resistivity and fundamental water quality parameters such as pH, electrical conductivity and total hardness. This innovative correlation methodology not only enhances the understanding of subsurface water quality with precision but also introduces a cost-effective alternative to the traditional drilling approach. The transformative impact of logarithmic analysis on resistivity values is proved to be essential in uncovering significant correlations with water quality parameters. As a result, this methodology facilitates informed decision-making in groundwater quality assessment, optimizing resource allocation and mitigating the risks associated with investments in tube wells of undesirable water quality. The findings of the present work contribute to the dynamic field of geophysics in hydrogeology, underscoring the potential for sustainable and economically viable exploration of water resources. Analyzing resistivity values logarithmically helps identify important links with water quality, transforming how we perceive and manage groundwater, making it more cost-effective and dependable.

Keywords: *Conductivity, Correlation, Forward Modeling, Scatter Plots, Vertical Electrical Sounding (VES)*

Acknowledgements: The water resources board is greatly acknowledged for their valuable support and collaboration in this research.

DEVELOPMENT OF ACTIVATED COCONUT SHELL CHARCOAL AND CARBON NANOTUBES COMPOSITE AS COUNTER ELECTRODE FOR DYE-SENSITIZED SOLAR CELL APPLICATIONS

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Dye-sensitized solar cells (DSSCs) are the potential candidates for low-cost third generation photovoltaic devices, and they have attracted increasing attention. Typically, a DSSC device comprisesthree major components: a dye-sensitized semiconductor photoanode, an iodide electrolyte, and a counter electrode (CE). The CE significantly influences the photovoltaic performance of DSSCs, serving as a conducting layer with electrocatalytic functions to catalyse the redox couple regeneration reaction and collect electrons from the external circuit. Generally, Platinum (Pt) CE is the preferred material due to its high electrocatalytic activity in redox reactions and good conductivity. However, since Pt is a noble metal, there is a need to develop low-cost alternatives with high conductivity and excellent electrocatalytic activity. Considering these properties, carbonaceous materials emerge as promising candidates for CE materials comparedwith theother types of CEs. In this study, a composite consisting of activated coconut shell charcoal (ACSC) and carbon nanotubes (CNTs) was studied as a potential CE material for DSSCs. This ACSC/CNTs composite CE was fabricated using the spray method and used as an alternative to Pt CE. During the fabrication of composite CE, the amounts of ACSC and CNTs were optimized for device performance. The photovoltaic performance of the DSSCs were studied using I-V measurements under the 100 mW cm^{-2} (1.5 AM) light illumination. The best performance was exhibited by the composite made with 0.3 g ACSC and 0.2 g CNT added to the composite CE. The solar cell efficiency increased from 4.03 % for pure ACSC and5.49 % for the optimized composite electrode, which is comparable to the efficiency of 6.41 % obtained for Pt electrode. This impressive increase in efficiency can be attributed to the highly porous nanostructure of the ACSC/CNT composite, providing more electron pathways and reaction sites for triiodide ion reduction, as confirmed by Scanning Electron Microscopy, X-ray diffraction, and Raman spectroscopy. The excellent electro-catalytic activity exhibited by the new CE is confirmed by Electrochemical Impedance Spectroscopy and Cyclic voltammetry, further supported by Tafel plot analysis. This result provides a cost-effective method to fabricate efficient CEs for DSSCs.

Key words: *Dye-Sensitized Solar Cells, Counter Electrode, Activated Coconut Shell Charcoal, Carbon Nanotubes*

INTERPRETATION OF SATELLITE GRAVITY ANOMALIES TO ESTIMATE THE CONTINENTAL CRUST - OCEANIC CRUST BOUNDARY OVER THE EASTERN PART OF SRI LANKA

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Recognizing the Continent-Ocean Boundary (COB) is crucial for both the exploration of hydrocarbons and the study of tectonic plate evolution. However, the COB in Sri Lanka has not been thoroughly investigated and hence, the objective of the present work is to delineate the COB along the eastern coastline of Sri Lanka, an area recently discovered to have a significant potential for hydrocarbon resources. In this work, satellite gravity data from the Eastern coastal region of Sri Lanka were used. The 2D gravity modelling was performed using an in-house software on the Mathematica platform. The gravity anomaly resulting from the seawater column was determined using the available data, and forward gravity computations were performed along the eastern coast, reaching depths up to 30 km. Ten profiles, each with an average length of 180 km, were modelled and named as Line 01, Line 02, Line 03, up to Line 10.The results indicate that the COB is situated approximately 17 km off the coast, and approximately the upper boundary of the COB located 20 km far away from the coast and the lower boundary was located approximately 14 km away. Those profiles had various thickness on their oceanic crust which vary from the 6.5 km to 7.5 km. In Line 02, 03, 04, 05 and 08 has pocket like sediment deposition on the COB which reach up to average 7 km thickness. The other profiles (Line 01, 06, 07, 09, 10) have less sediment deposition than previous profiles which reach up to 4 km thickness. However, all the profiles in the Northern part of the Lanka basin have a higher sediment thickness than anticipated.

Keywords: *Continental Crust-Oceanic Crust Boundary, Gravity Anomalies, Hydrocarbon Exploration, Sediment Thickness*

Acknowledgement: Professor D.A. Tantrigoda is greatly acknowledged for providing the in-house software.

DEVELOPMENT OF PVDF POLYMER-BASED GEL POLYMER ELECTROLYTE FOR LITHIUM-ION BATTERIES

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Lithium-ion batteries are rechargeable and have a high energy density and used immensely in energy storage. As a conductive medium, the main function of the electrolyte in a Li-ion battery is to make it easier for lithium ions to travel between the anode and cathode. Higher viscosity gel electrolytes improve safety and flexibility for a range of applications, moving the field of lithium-ion battery technology forward. This study focuses on a specific gel electrolyte with the composition consisting of Polyvinylidenefluoride (PVDF) as the polymer, ethylene carbonate (EC) and dimethyl carbonate as plasticizers, and $LiClO_4$ as the salt. The significance of each component in this formulation is examined for its impact on the electrolyte performance. First, the effect of incorporating Li ions into the PVDF-based gel electrolyte on ionic conductivity was studied by adding Li salt to polymer with different weight ratios. The gel polymer electrolyte without Li ions showed a conductivity of $3.00 \times 10^{-5}\,\mathrm{S\,cm^{-1}}$ at room temperature. Among the ratios (0.1, 0.2, 0.3, 0.4, 0.6, 0.8), 0.2 Li ion weight ratio showed the highest conductivity of $6.86 \times 10^{-3}\,\mathrm{S\,cm^{-1}}$ at room temperature.Then, keeping other components constant, the conductivity was further improved by varying EC content to the polymer with weight ratios of 0.75, 1.00, 1.25 and 1.50. The highest conductivity of $7.27 \times 10^{-3}\,\mathrm{S\,cm^{-1}}$ at room temperature was observed for the 1.5 EC weight ratio, suggesting a synergistic effect in enhancing electrochemical performance. Interactions between polymers and salts were confirmed through FTIR measurements. The XRD study showed a distinctive peak at approximately $2\Theta = 20^{o}$ in the pure PVDF matrix, indicative of a highly crystalline phase resulting from polymer chain ordering. However, upon the addition of $LiClO_4$ salt and EC, the peak was broadened in the gel polymer electrolyte, signifying a reduction in crystallinity and an enhancement of the amorphous phase. This widening implies an improved activation of ion migration, fostering effective interaction between the polymer and Lithium ions. The findings provide compelling evidence for increased ion conductivities with the incorporation of $LiClO_4$ salts into the polymer matrix.

Key words: *Lithium-ion Batteries, Gel Polymer Electrolytes, PVDF Polymer, Conductivity*

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